FINAL REPORT

Las Campanas Water Supply Project Feasibility Study

Submitted to

LAS CAMPANAS
SANTA FE

Prepared by

CH2MHILL

October 2001

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Executive Summary

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In January 2001, CH2M HILL was hired by Las Campanas Santa Fe (Las Campanas) to prepare an engineering feasibility study for a viable, long-term water supply for the full build out of the development. The goal of the study is the identification of a preferred water supply alternative that is reliable and as independent as possible from existing supplies.

Water demands for Las Campanas are presently about 1,000 to 1,100 acre-feet per year (ac-ft/yr) with approximately 170 ac-ft/yr for residential use, 60 to 80 ac-ft/yr for community facilities, and 800 to 850 ac-ft/yr for irrigation use, primarily at the 36-hole golf course. At full buildout, annual demands are anticipated to be about 1,800 ac-ft/yr (1.6 million gallons per day [mgd] or 1,120 gallons per minute [gpm]), 800 ac-ft/yr (0.71 mgd or 496 gpm) for residential use, 70 ac-ft/yr (0.06 mgd or 43.4 gpm) for community facilities, and 880 ac-ft/yr (0.79 mgd or 546 gpm) for irrigation. Annual demands will likely be 10 to 15 percent less than cited above during years having strong monsoon season rains. Peak-day demands could be as much as twice the values cited above (i.e., as much as 3.2 mgd or 2,200 gpm, 1.6 mgd for irrigation, and 1.6 mgd for residential and community use).

Las Campanas' existing water supply comes from the City's Buckman wellfield, which is operated by the Sangre de Cristo Water Division (SDC). Based on an agreement signed with the SDC in 1987, the amount of water available to Las Campanas is 1,600 ac-ft/yr with delivery rates at no more than 25 percent of the defined 5,100 gpm hydraulic capacity of the 20-inch Buckman transmission line (1,275 gpm); or 50 percent of the capacity of wells 3, 4, 5, and 6, whichever is less. Because of the problems with declining well yields described below, Las Campanas has taken the applicable peak delivery rate under the agreement to be 1,275 gpm. Under the agreement, delivery at even higher rates is possible provided SDC does not need the capacity to serve other customers. The agreement is written to run through December 2012 with provision for three 5-year extensions.

The Tesuque Formation aquifer in which the Buckman wellfield is developed has experienced declining water levels for decades. Originally constructed in the early 1970s, the Buckman wells have declined dramatically in yield in recent years. Recent evidence suggests that the sustainable capacity of wells 3, 4, 5, and 6 would appear to be only about 2,000 ac-ft/yr (1.8 mgd or 1,240 gpm). However, well 5 has been recently shut down because of poor water quality conditions, and declining water levels in the other Buckman wells and increased pumping lifts make delivery of 1.8 mgd questionable. Consequently, the sustainable capacity of the Buckman wells 3, 4, and 6 is probably only about 1,800 to 2,000 ac-ft/yr (meaning that the sustainable 50 percent delivery capability under the Las Campanas agreement may be only 900 to 1,000 ac-ft/yr, or 550 to 625 gpm).

Efforts to rehabilitate, deepen, and change out pumps to more efficiently transport water up the Buckman delivery line (or other measures such as adding additional wells) may help somewhat, but the long-term prospects for significant improvement of capacity of the Buckman wellfield does not appear promising.

In 1994, the County of Santa Fe developed an agreement with Las Campanas that required the identification and construction of a replacement water delivery system by the year 2004. Consequently, this feasibility study was undertaken to identify a preferred alternative for that new water system and produce conceptual design drawings and cost estimates for a new water supply system for Las Campanas.

Four potential Las Campanas water supply alternatives were identified and subjected to evaluation and screening:

- Buckman Wellfield — remain on the City's Buckman well system
- New Wells — construct new wells (at least two, and possibly three) in the nearby Tesuque Formation aquifer
- Infiltration Gallery — construct infiltration gallery (approximately 1,700 feet) parallel to the Rio Grande at Buckman
- River Intake — construct new screened intake structure on the east bank of the Rio Grande at Buckman; intake sized to accommodate future connection by City and County of Santa Fe

Existing maps, data, hydrologic/engineering data, and reports were reviewed and field investigations undertaken to evaluate the advantages and disadvantages of each of the four alternatives. Several special investigations and hydraulic modeling were conducted at the Buckman riverfront to examine the likely capacities of the Infiltration Gallery and River Intake alternatives. A favorable location just downstream of the Buckman Road terminus on the Rio Grande was identified for a river intake on the east bank. Hydraulic modeling suggests that an intake at this location is probably capable of operating at diversion rates of up to 25 cfs at extremely low river flows (e.g., 200 cfs). Additional surveys made at low-flow conditions in fall 2001 are needed to confirm this conclusion.

The Buckman Wellfield, New Wells, and Infiltration Gallery alternatives were judged to be less compatible with a regional water supply plan since they result in little additional new supply. The hydrogeologic situation with the Tesuque Formation where the Buckman and New Wells alternatives would be located wellfield is not favorable. The permitting and regulatory issues related to an expanded Buckman or New Well supply are problematic. The Infiltration Gallery alternative is made unfavorable by the likely adverse impacts to the riverfront environment, severe construction difficulties, potential long-term clogging problems, and the limited yield (estimated at 1,800 ac-ft/yr with no peaking capability).

In contrast, the River Intake alternative has the potential to supply as much as 15,000 ac-ft/yr of new water, with somewhat higher rates possible for peaking. Moreover, overall costs and environmental impacts would appear to be better than the Infiltration Gallery alternative. Consequently, and based on the results of this feasibility investigation, CH2M HILL has identified the River Intake at Buckman as the preferred alternative for a long-term, reliable water supply for Las Campanas.

Section 1.
Introduction

Section 1
Introduction

Located some 12 miles northwest of Santa Fe, New Mexico (Figure 1-1), Las Campanas is a planned real estate development that presently comprises about 300 homes, two 18-hole golf courses, a club house, fitness center, tennis courts, an equestrian center, and various landscaped and common areas. Upon full buildout in 10 to 15 years, Las Campanas will include approximately 1,400 homes and several new commercial and office facilities. Currently, water for Las Campanas is provided via the Buckman wellfield system located several miles to the west. Growing concerns about the long-term sustainability of the Buckman wellfield and an agreement entered into with the County of Santa Fe in 1994 requiring a replacement water supply to Buckman by 2004, has led Las Campanas to seek an independent, assured water supply.

In January 2001, CH2M HILL was hired by Las Campanas to prepare an engineering feasibility study for a reliable, long-term water supply for the development. The key element of the study is the identification of a preferred water supply plan for full buildout of the development that is reliable and as independent as possible from existing supplies. The study included:

- Collection and review of existing data, maps, and reports pertinent to water supply alternatives and water resource issues.
- Participation in numerous meetings and discussions with State and Federal resource and regulatory agencies and various local governmental entities regarding the diversion of water from the Rio Grande.
- Identification and comparison (using 'screening criteria') of various water supply alternatives, including:
  - Groundwater — staying on the City of Santa Fe's (City) Buckman wellfield system or developing new wells in the Tesuque Formation aquifer near Las Campanas.
  - Surface water — a new diversion facility on the Rio Grande near Buckman, with diversion affected by a subsurface (infiltration) or surface (river intake) system.
  - Wastewater — use of treated effluent from the City's treatment plant in combination with either of the proposed surface water or groundwater alternatives. Wastewater would only be used to meet nonpotable irrigation demands at the Las Campanas golf course and common landscaped areas. Thus, effluent does not meet the goal of being an independent supply capable of meeting all Las Campanas needs but is recognized as a partial solution if coupled with one of the other alternatives.
- Preparation of conceptual layouts, preliminary drawings, and cost estimates for several of the most promising alternatives.

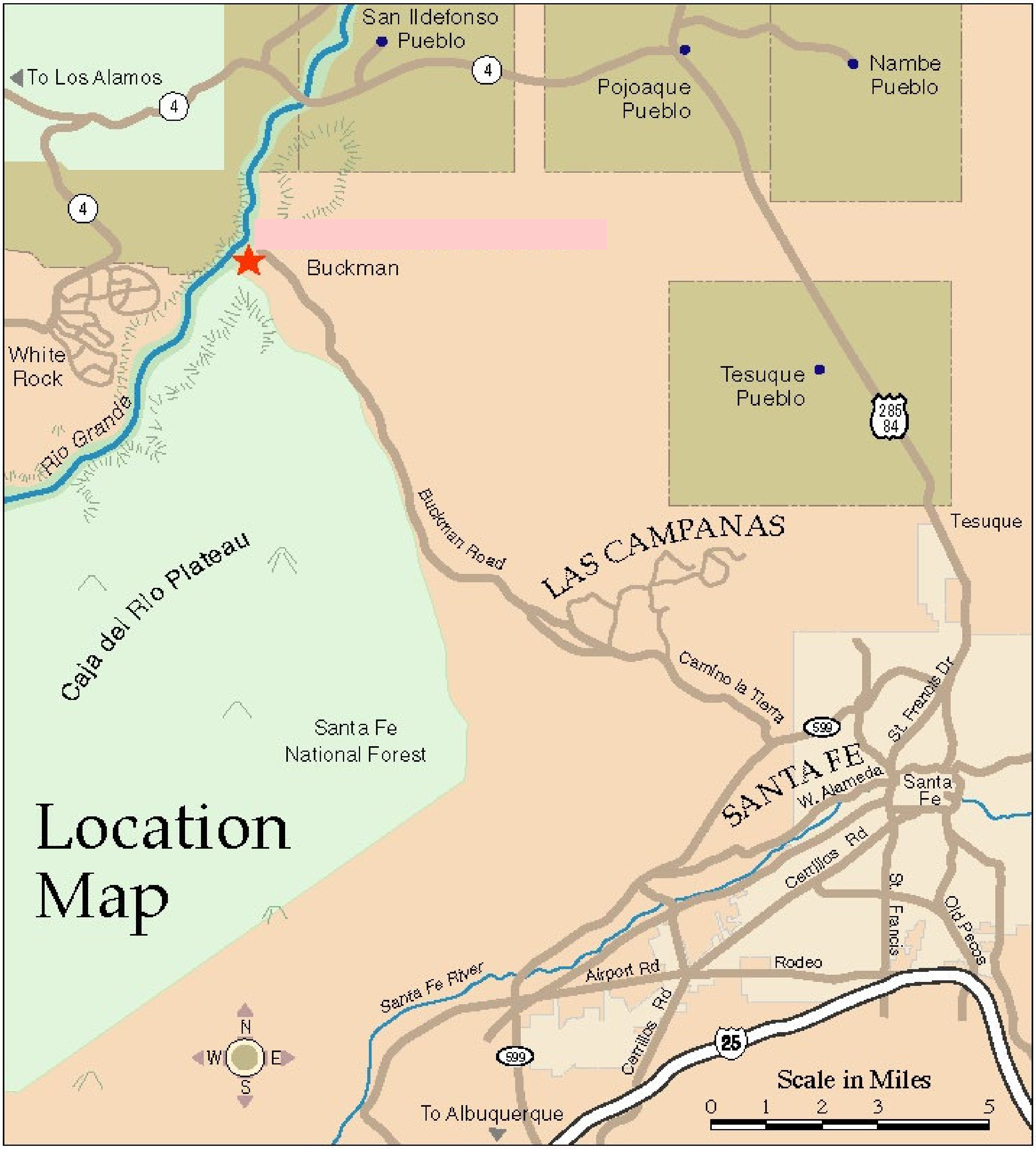


Figure 1-1. Las Campanas - Buckman Area Location Map

- Preparation of a report with conclusions and recommendations for a preferred alternative for a Las Campanas water supply diversion and delivery system.

As of summer 2001, a number of water supply studies and environmental investigations were being undertaken by the City and County of Santa Fe and Los Alamos County. This work could lead to a regional water plan for the Santa Fe area. Such a plan could involve diversions from the Rio Grande in the Otowi, Buckman, or Pena Blanca areas, expanded reuse of wastewater effluent, improvements to existing groundwater or surface water (Santa Fe Canyon) delivery systems, new conservation measures, and various schemes to maximize return flow credits for water rights purposes. A host of Federal and State agencies are involved, including the U.S. Forest Service (USFS), U.S. Bureau of Reclamation (USBR), U.S. Bureau of Land Management (BLM), U.S. Bureau of Indian Affairs (BIA), several Pueblos, the New Mexico Environment Department (NMED), New Mexico Department of Game and Fish, and the Office of the New Mexico State Engineer (OSE).

The results of this report are tempered by the above situation and the need to make a water supply plan for Las Campanas compatible with the eventual regional plan. The hydrologic and engineering evidence developed in our investigations indicates that a direct diversion of Rio Grande water using a river intake in the Buckman riverfront area is technically feasible and probably has the best potential for overall compatibility with a regional water plan for the Santa Fe area.

In 1994, an agreement was developed whereby Las Campanas provided Santa Fe County a $7 million escrow bond and agreed to identify and construct a 'replacement' water delivery system (i.e., replacement for the existing supply from the Buckman wellfield) by 2004. This report is intended as the first major step toward that new system.

Section 2.
Las Campanas Water Resources Overview

Section 2
Las Campanas Water Resources Background

Water Demands

Water demands for Las Campanas are presently about 1,000 to 1,100 acre-feet per year (ac-ft/yr) with approximately 170 ac-ft/yr for residential use, 60 to 80 ac-ft/yr for community facilities, and 800 to 850 ac-ft/yr for irrigation use, primarily at the 36-hole golf course. At full buildout, annual demands are anticipated to be about 1,800 ac-ft/yr (1.6 million gallons per day [mgd] or 1,120 gallons per minute [gpm]), 800 ac-ft/yr (0.71 mgd or 496 gpm) for residential use, 70 ac-ft/yr (0.06 mgd or 43.4 gpm) for community facilities, and 880 ac-ft/yr (0.79 mgd or 546 gpm) for irrigation. Annual demands will likely be 10 to 15 percent less than cited above during years having strong monsoon season rains. Peak-day demands could be as much as twice the values cited above (i.e., as much as 3.2 mgd or 2,200 gpm, 1.6 mgd for irrigation, and 1.6 mgd for residential and community use).

Given the short time to anticipated full buildout at Las Campanas (10 to 15 years), this report assumes the need to provide for a full supply of 1,800 ac-ft/yr or 1,120 gpm (with provision for peak-day delivery capacity of about 2,200 gpm) as soon as practicable.

A breakdown of the current and projected water demands for the Las Campanas development is shown in Tables 2-1 and 2-2 and Figure 2-1.

TABLE 2-1
Summary of Las Campanas Projected Water Demands at Full Buildout

Type of Use	Water Demand (ac-ft/yr)	Residential Per Capita Use[a] (gpcd)
Golf Course Irrigation	800	
Community Area/Park Landscape Irrigation	83	
Community Facilities	71	
Residential Housing	801	168
Unaccounted for Water	35	
Total Projected Demands	1,791	

[a] Residential per capita use is based on an average of 3 persons per dwelling.

Note: gpcd = gallons per capita per day.

TABLE 2-2
WATER USE PROJECTIONS at BUILD OUT

STREETSCAPES

ELEMENT SUMMARY		**Projected Use**	
Entry Features		7,030,027	Annual Gallons
Permanent Streetscapes		9,160,109	Annual Gallons
Temporary Streetscapes		280,001	Annual Gallons
	Sub-Total	16,470,137	
	Acre Feet	50.55	

ENTRY FEATURES - Projected Build Out

			Year Completed			
1	Pojoaque Ridge	Pojoaque Ridge	1999	51,633		2000/ 1999 Average (with September-December 1999 used to complete 2000 annualized numbers)
2	Estates III Entrance	Sierra Rosa	1999	150,747		2000/ 1999 Average (with September-December 1999 used to complete 2000 annualized numbers)
3	Estates V-2 Wildhorse	Wildhorse	1999	98,173		2000/ 1999 Average (with September-December 1999 used to complete 2000 annualized numbers)
4	Estates V-3 Koshari 1	Koshari (E)	1999	96,540		2000/ 1999 Average (with September-December 1999 used to complete 2000 annualized numbers)
5	Estates V-3 Koshari 2	Koshari (W)	1999	12,727		2000/ 1999 Average (with September-December 1999 used to complete 2000 annualized numbers)
6	Estates V Entry	Greywolf	1999	1,972,533		2000/ 1999 Average (with September-December 1999 used to complete 2000 annualized numbers)
7	LC-Club Guard House	Las Campanas	2000	1,195,147		2000 Only
8	Ranch Estates	Ranch Estates Road	2002	*120,000*		Estimated
9		Calle Chiripa	2001	*99,000*		Estimated
10		Juniper Hill	2001	*666,667*		Estimated- Clubhouse Drive as reference
11		Palomita (both sides	2002	*198,000*		Estimated - 2 entries at 11,000 gallons each.
12		De Oro (South)	2004	*666,667*		Estimated- Clubhouse Drive as reference
13		De Oro (North)	2006	*166,667*		Estimated- Estates III as reference
14		Trailhead (North)	2005	*666,667*		Estimated- Clubhouse Drive as reference
15		De Oro Clusters	2006	*868,860*		Estimated - Koshari E prototype * 9 entries
	Subtotal				7,030,027	

PERMANENT STREETSCAPES - Projected Build Out

		Year Completed			
1	Casitas	2000	4,402,600		2000 Annualized use (with September-December 1999 used to complete 2000 annualized numbers)
2	Los Santeros	2002	*978,000*		Estimated based on current Club Casita use
3	Pueblos	2002	*693,236*		Estimated based on current streetscape design
4	Park Estates	2002	*745,970*		Estimated based on current streetscape design
5	Parcel 'O'	2005	*840,303*		Estimated based on current plat concept
6	Clubhouse Drive	2002	*1,500,000*		Estimated based on relative comparables
	Subtotal			9,160,109	

TEMPORARY IRRIGATION-Projected Build Out

Assume 25% of Annualized use during construction 280,001

Note: numbers in boxes are estimates

Source: Based on written communication with EDAW (12-Dec-00)

TABLE 2-2 CONTINUED
WATER USE PROJECTIONS at BUILD OUT
PARKS

	PARK SIZE		LANDSCAPE ALLOCATION BY TYPE														
				Paving		High Image		Intimate Garden		Enhanced Native		Restored Native		Native		Annual Water use	Year Completed
LC Name	Acres (1)	Sq Feet	%	Square Feet	%	Square Feet	%	Square Feet	%	Square Feet	%	Square Feet	%	Square Feet	%	acre-ft	
1 Pueblos Park	2.1	91,476	10%	9,354	10%	51,552.00	56%	-	0%	30,570	33%	-	0%	-	0%	10.28	2002
2 Park Estates Park	5.3	230,868	22%	51,440	10%	21,311.00	6%	12,772	39%	89,533	24%	55,812	24%	-	0%	6.03	2002
3 Parcel 'O' East	1.0	43,560	5%	2,178	15%	6,534	10%	4,356	50%	21,780	20%	8,712	0%	-	0%	1.92	2005
4 Parcel 'O' West	1.0	43,560	5%	2,178	5%	2,178	20%	8,712	50%	21,780	20%	8,712	0%	-	0%	1.13	2006
5 Los Santeros Tract 'E' (2)	0.5	21,780	0%	-	75%	16,335	15%	3,267	10%	2,178	0%	-	0%	-	0%	0.78	2003
6 De Oro Tract F	0.7	30,928	0%	-	10%	3,093	5%	1,546	30%	9,278	55%	17,010	0%	-	0%	3.47	2006
7 De Oro Tract I	2.7	117,612	5%	5,881	10%	11,761	10%	11,761	40%	47,045	35%	41,164	20%	23,522	20%	3.23	2004
8 De Oro Tract M	0.1	4,356	0%	-	0%	-	10%	436	30%	1,307	60%	2,614		-	0%	0.89	2005
9 De Oro Tract K	0.9	37,462	10%	3,746	10%	3,746	15%	5,619	35%	13,112	30%	11,238	20%	7,492	20%	2.08	2006
10 Parcel 'D' West	1.0	43,560	5%	2,178	10%	4,356	10%	4,356	40%	17,424	35%	15,246		-	0%	1.92	2007
11 Parcel 'D' East	1.0	43,560	5%	2,178	5%	2,178	15%	6,534	40%	17,424	35%	15,246		-	0%	1.08	2007
(1) per preliminary plat																	
(2) estimated		708,721		79,133		123,044		59,359		271,430		175,754		31,015		**32.79**	
	acres =	16.27															

Source: Based on written communication with EDAW (12-Dec-00)

TABLE 2-2 CONTINUED
WATER USE PROJECTIONS at BUILD OUT
COMMUNITY FACILITIES

ELEMENT SUMMARY

Club Amenities-Permanent	23,168,640	(1)
Acre Feet	**71.11**	

CLUB AMENITIES - Projected

Las Campanas Reference	Year Completed	January Demand	February Demand	March Demand	April Demand	May Demand	June Demand	July Demand	August Demand	September Demand	October Demand	November Demand	December Demand	Annual Demand	
1 4 East Bathroom	1999													24,000	2000 Peak Month annualized
2 13 East Bathroom	1999													19,320	2000 Peak Month annualized
3 7 West Bathroom/ Halfway House	1999													25,440	2000 Peak Month Annualized + Estimated Halfway house impact of 2,000 gpm for 8 months
4 12 West Bathroom	1999													25,660	Estimated based on 4/13 East Average
5 Driving Range Bathroom	1999													20,880	2000 Peak Month annualized
6 LC Club #1 Meter	1999				13,780	590	83,570	76,580	68,590	*62,640*	*54,120*	*8,410*	*5,520*	747,600	2000 Actual(January-August)+1999 Actual Sept-Dec
7 LC Club #2 Meter	1999				2,720	200	15,780	13,590	14,560	*6,380*	*5,640*	*790*		119,320	2000 Actual(January-August)+1999 Actual Sept-Dec
8 LC Club #3 Meter	1999													1,666,800	2000 Peak Month annualized
9 Log Cabin	1999													46,800	2000 Peak Month annualized
10 Equestrian Barn #1	1999													7,200	2000 Peak Month annualized
11 Equestrian Barn #2	2010													3,600	2000 Peak Month annualized
12 Equestrian Exercise Pen	2000													1,320	2000 Peak Month annualized
13 Indoor Arena	2010					130	90	50						600	2000 Peak Month annualized
14 Equestrian Irrigation #4	2010					89,900	44,600	39,400	1,118,600	*337,100*	*191,800*	*29,700*		3,942,200	2000 Actual(January-August)+1999 Actual Sept-December. Assumes additional stalls and barn expansion = 10,000 gpm
15 Spa and Tennis Center Boiler	2000		52,900	144,200	114,900	700,500	1,181,100	961,100	961,100	*734,500*	*531,200*	*159,200*	*191,200*	11,463,800	2000 Actual(January-August)+1999 Actual Sept-Dec
16 Spa and Tennis Irrigation #1	2000													904,800	2000 Peak Month annualized
17 New Maintenance Facility	2005													480,000	Assume 20,000 gpm based on current temp facility us
18 Sewer Co-op Flush Headworks	1999													240,000	2000 Peak Month annualized
19 LC GCM Domestic	2000													288,000	Reduced 40% from historical due to new facility
20 Swim and Tennis Temp (Accountin	2000						287,590	262,220	286,120	*357,310*	*318,020*	*59,390*		3,141,300	2000 Actual(January-August)+1999 Actual Sept-Dec
														23,168,640	

Source: Based on written communication with EDAW (12-Dec-00)

(1) Assumes No Temporary Facilities at Build Out

TABLE 2-2 CONTINUED
WATER USE PROJECTIONS at BUILD OUT
RESIDENTIAL ALLOCATIONS

	Total Units		Pro Forma		Recommended-Lo		Recommended-Hi	
			Factor	Extended	Factor	Extended	Factor	Extended
Estates III		181.00						
Single Family Lots w/ Guest House	181.00		0.50	90.50	0.60	108.60	0.75	135.75
Estates IV		99.00						
Single Family Lots w/ Guest House	99.00		0.50	49.50	0.60	59.40	0.75	74.25
Estates V		160.00						
Unit 1: Single Family Lots w/ Guest House	31.00		0.50	15.50	0.60	18.60	0.75	23.25
Unit 1: Compound Lots	4.00		0.75	3.00	0.75	3.00	1.00	4.00
Unit 2: Single Family Lots w/ Guest House	83.00		0.50	41.50	0.60	49.80	0.75	62.25
Unit 3: Single Family Lots w/ Guest House	42.00		0.50	21.00	0.60	25.20	0.75	31.50
Estates VII		126.00						
Unit 1:Single Family Detached Small Lots	46.00		0.25	11.50	0.50	23.00	0.60	27.60
Unit 2: Single Family Lots w/ Guest House	80.00		0.50	40.00	0.60	48.00	0.75	60.00
Ranch Estates		27.00						
Single Family Lots with Barn/ Paddock	27.00		0.50	13.50	0.75	20.25	1.00	27.00
Pueblos		37.00						
Single Family Detached/ Small Lots	37.00		0.25	9.25	0.50	18.50	0.50	18.50
Estates VIII		104.00						
Unit 1: Single Family Detached Small Lots	43.00		0.25	10.75	0.60	25.80	0.75	32.25
Unit 2: Single Family Detached Small Lots	49.00		0.25	12.25	0.60	29.40	0.75	36.75
Unit 3: Single Family Detached Small Lots	12.00		0.25	3.00	0.60	7.20	0.75	9.00
Los Santeros		194.00						
Compound Lots	3.00		0.75	2.25	0.75	2.25	1.00	3.00
Single Family Detached with Guest House	65.00		0.50	32.50	0.60	39.00	0.75	48.75
Single Family Attached	126.00		0.25	31.50	0.50	63.00	0.50	63.00
The Enclaves		140.00						
Single Family Detached Lots w/ Guest House	140.00		0.50	70.00	0.60	84.00	1.00	140.00
Estancia Real		12.00						
Single Family Detached Lots w/ Guest House	12.00		0.50	6.00	0.50	6.00	0.75	9.00
Parcel 'O'		115.00						
Single Family Detached/ Small Lots	78.00		0.60	46.80	0.60	46.80	0.60	46.80
Single Family Detached Lots w/ Guest House	3.00		0.50	1.50	0.50	1.50	1.00	3.00
Single Family Attached	34.00		0.25	8.50	0.30	10.20	0.50	17.00
Casitas		36.00						
Single Family Attached (Existing)	14.00		0.25	3.50	0.30	4.20	0.50	7.00
Single Family Attached (Under Construction)	22.00		0.25	5.50	0.30	6.60	0.50	11.00
Parcel R		12.00						
Single Family Attached	12.00		0.25	3.00	0.30	3.60	0.50	6.00
Parcel D		122.00						
Single Family Detached Lots w/ Guest House	79.00		0.50	39.50	0.60	47.40	0.75	59.25
Single Family Attached	43.00		0.25	10.75	0.30	12.90	0.50	21.50
Swimming Pools								
Gouris				0.07		0.07		0.07
Berger				0.03		0.03		0.03
Cunningham				0.02		0.02		0.02
Rosemurgy				0.66		0.66		0.66
Future Pools (20 Total at current average)						3.88		3.88
	1,365	1,365		583.33		768.86		982.06
	54.00		0.50	27.00	0.60	32.40	0.75	40.50
Variance				610.33		801.26		1,022.56

Note: numbers in boxes are estimates

Source: Based on written communication with EDAW (12-Dec-00)

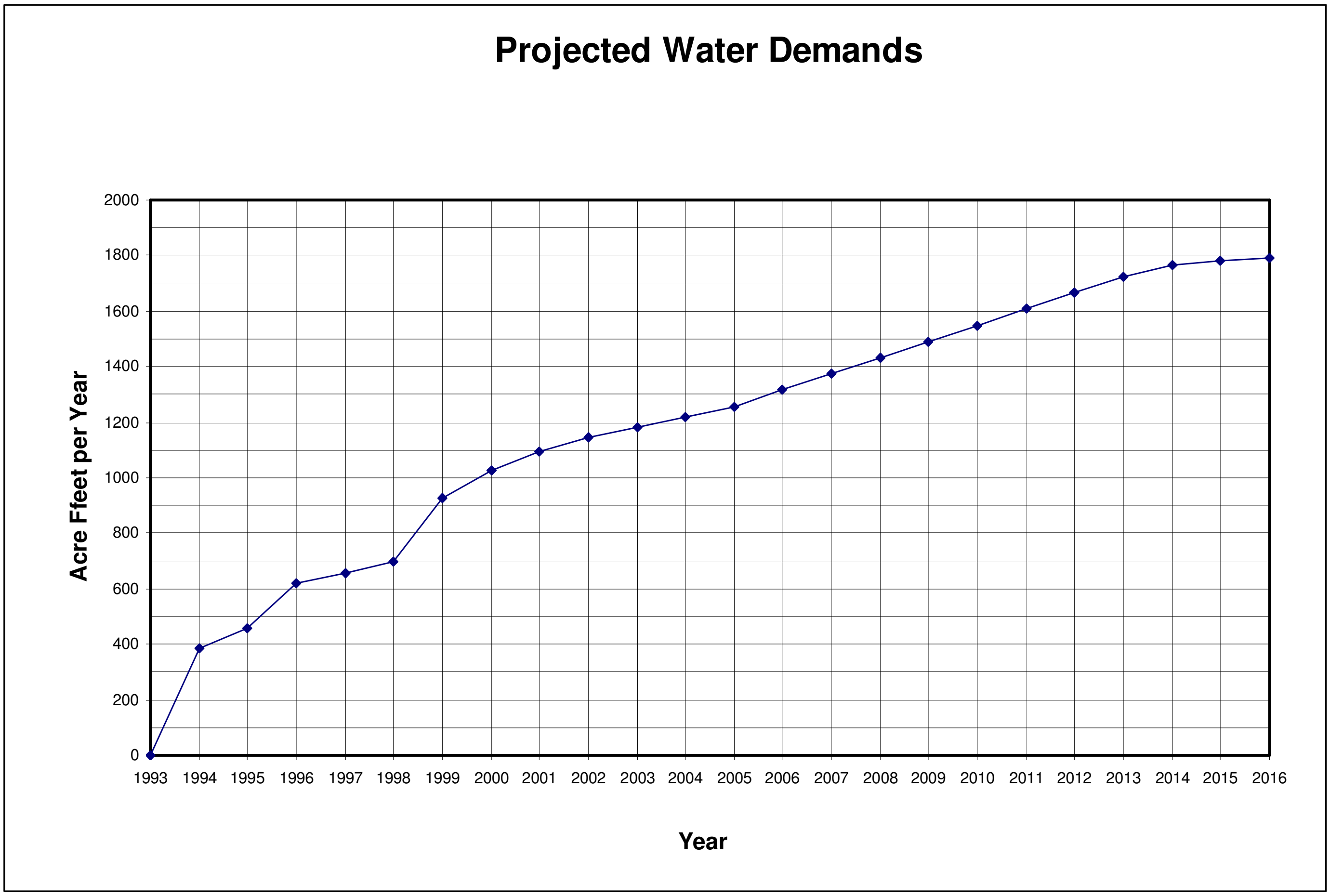


Figure 2-1. Las Campanas Projected Water Demands Through Buildout

Water Rights

Las Campanas' water rights comprise approximately 600 ac-ft/yr of 'native' Rio Grande rights (with more under acquisition) and up to 1,600 ac-ft of San Juan-Chama (SJC) water leased from the City of Albuquerque's 48,200 ac-ft/yr allocation. The native rights have already been transferred to the City's Buckman wellfield (see below). The lease agreement for Albuquerque's SJC water is scheduled to expire in 2011. Consequently, Las Campanas' ongoing acquisition program will replace the leased Albuquerque SJC water when it is no longer available.

Existing Las Campanas Water Supply

Las Campanas' existing water supply comes from the City's Buckman wellfield, which is operated by the Sangre de Cristo Water Division (SDC) (see Figure 2-2). Based on an agreement signed with the SDC in 1987, the amount of water available to Las Campanas is 1600 ac-ft/yr with delivery rates at no more than 25 percent of the defined 5,100 gpm hydraulic capacity of the 20-inch Buckman transmission line (1,275 gpm) or 50 percent of the capacity of wells 3, 4, 5, and 6, whichever is less. Because of the problems with declining well yields described below, Las Campanas has taken the applicable peak delivery rate under the agreement to be 1,275 gpm. Based on the agreement, delivery at even higher rates is possible provided SDC does not need the capacity to serve other customers. The agreement is written to run through December 2012 with provision for three 5-year extensions.

Under this agreement, Las Campanas has provided portions of its owned native Rio Grande water rights and leased SJC rights for use by the City in offsetting the effects of groundwater pumpage of the Buckman wellfield on the flow of the Rio Grande and its tributaries, the Rio Tesuque and Rio Pojoaque. Such offsets are required by and determined by the OSE using a groundwater model.

The Tesuque Formation aquifer in which the Buckman wellfield is developed has experienced declining water levels for decades. Originally constructed in the early 1970s, the Buckman wells have declined dramatically in yield in recent years. Recent evidence suggests that the sustainable capacity of wells 3, 4, 5, and 6 would appear to be only about 2,000 ac-ft/yr (1.8 mgd or 1,240 gpm). However, well 5 has been shut down because of poor water quality conditions, and declining water levels in the other Buckman wells and increased pumping lifts make delivery of 1.8 mgd questionable on a sustained basis. Consequently, the sustainable capacity of the Buckman wells 3, 4, and 6 is probably only about 1,800 to 2,000 ac-ft/yr (meaning that the 50 percent delivery capability under the Las Campanas agreement may be only 900 to 1,000 ac-ft/yr, or 550 to 625 gpm). Efforts to rehabilitate, deepen, and change out pumps to more efficiently transport water up the Buckman delivery line (or other measures such as adding additional wells) may help somewhat, but the long-term prospects for significant improvement of capacity of the Buckman wellfield does not appear promising.

Thus, even without further development of homes at Las Campanas, the existing water supply from the Buckman wellfield is barely adequate to meet existing demands.

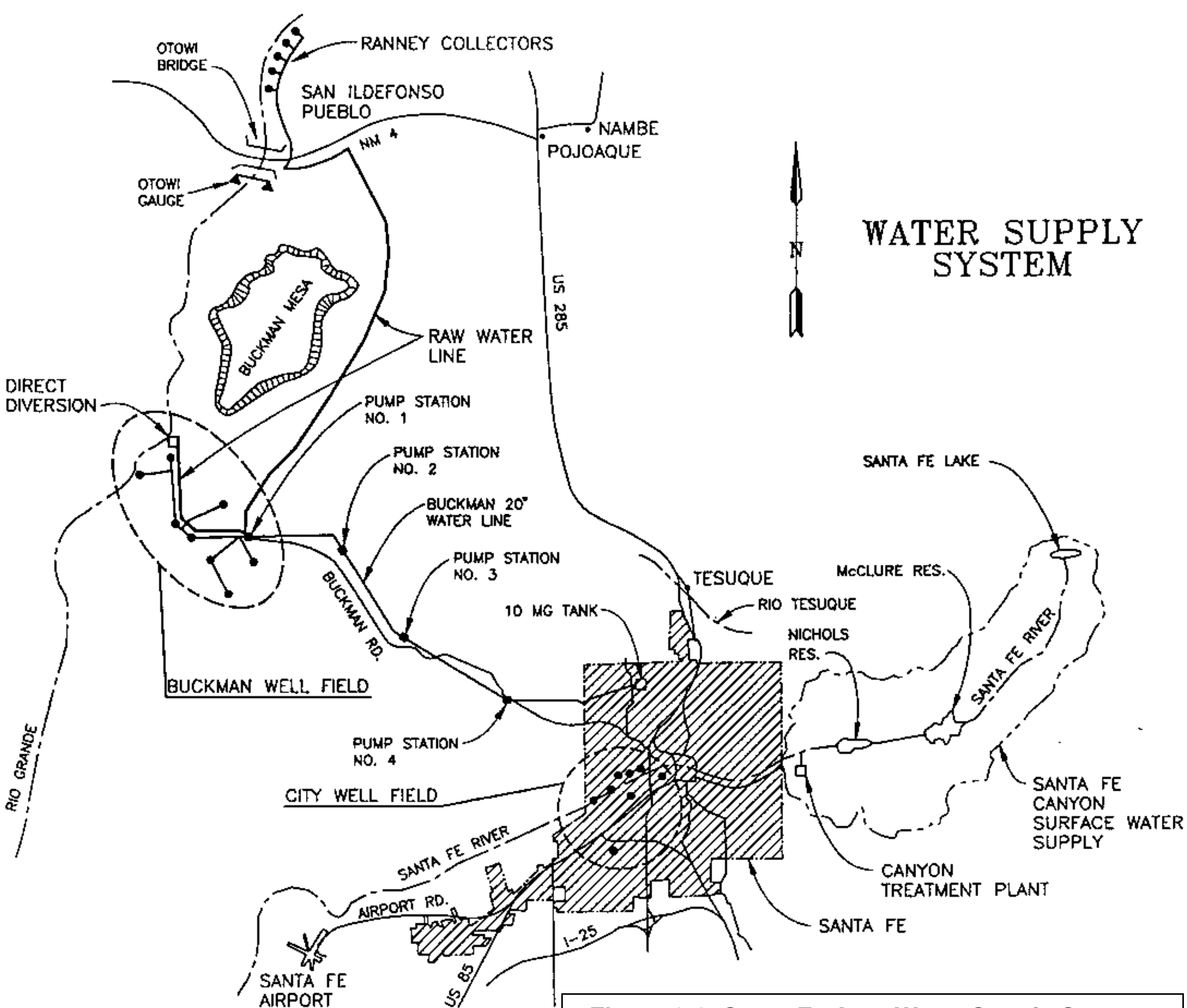


Figure 2-2. Santa Fe Area Water Supply System

Experience in summer 2000 and 2001 has confirmed this situation and suggests that the overall Buckman delivery system and tie-in to the Las Campanas water distribution system is inadequate to meet peak summertime demands (Las Campanas, 2001).

The City's other two sources of water supply are the City wellfield located in Santa Fe proper, and the Santa Fe River watershed surface supply that includes McClure and Nichols Reservoirs and the Canyon Water Treatment Plant (see Figure 2-2). Various investigations of the sustainable yield of the City wellfield have been made over the years (Boyle, 1997). The most recent evidence indicates that it can provide about 3,000 ac-ft/yr during 'normal conditions' and perhaps 25 percent less during dry years. The Santa Fe River system appears capable of providing 3,500 to 5,000 ac-ft/yr during normal to wet years, but dramatically less during drought years. For example, during the very dry year of 1951, yield of the Santa Fe River system fell to only 950 ac-ft/yr.

In summary, the total sustainable capacity of the existing Santa Fe area water supplies is probably on the order of about 11,000 to 13,000 ac-ft/yr. In recent years, regional water demands have been near the upper end of that range. This situation has culminated in a crisis in water supply for the Santa Fe area. Dry years in 1996 and 2000 led the City to impose conservation measures that included restrictions on outdoor irrigation. In recognition of this situation, Las Campanas officials in 1999 attempted to work out an agreement to provide the Las Campanas golf course with effluent from the City's wastewater treatment plant (WWTP) located some 6 miles south near the Santa Fe Municipal Airport (see Figure 1-1). A utility extension provision in the agreement would have made Las Campanas a customer of the City for potable water and wastewater treatment; thus, fulfilling the previously described 1994 'replacement' water supply agreement with Santa Fe County. Although the proposed agreement was supported by City staff, it was voted down by City Council in 2000.

Section 3.
Las Campanas Water Supply Alternatives

Section 3

Las Campanas Water Supply Alternatives

Based on the situation described above, the present study was undertaken to investigate independent water supply alternatives capable of providing a reliable water supply for the full buildout of Las Campanas — a total supply of some 1,800 ac-ft/yr (1,120 gpm or 1.6 mgd) with provision for peak demands about twice as high. Review of pertinent reports and data, discussions with local water resource experts and governmental officials, and engineering judgement led to the identification of the following potential alternatives.

A. **Buckman Wellfield** — remain on the City's Buckman well system. Various improvements would be needed to rehabilitate several wells, the pipeline, and pump stations. Little or no new conveyance or right-of –way would be required.

B. **New Wells** — construct new wells (at least two, and possibly three) in the nearby Tesuque Formation aquifer. New right-of-way would be needed for the wells, pump stations, and conveyance pipelines.

C. **Infiltration Gallery** — construct infiltration gallery (approximately 1,700-feet long) parallel to the Rio Grande at Buckman. New pump stations, a conveyance pipeline along Buckman Road, and a new water treatment plant at Las Campanas would be needed. Also required would be a sizeable storage reservoir on Las Campanas property to meet peak summer demands.

D. **River Intake** — construct new screened intake structure of the east bank of the Rio Grande at Buckman. Improvements would include a sedimentation basin on the terrace some thousand feet inland; and new pump stations and a conveyance pipeline along Buckman Road, and a new water treatment plant at Las Campanas.

Alternative A – Buckman Wellfield

Remaining on the Buckman wellfield system would entail Las Campanas gaining access to considerably more capacity of that system than is presently possible and making a number of improvements, the extent of which is difficult to define. For example, for Buckman to meet Las Campanas future summertime peak demands, more than 2,200 gpm would be needed (additional storage at Las Campanas could reduce this somewhat). This is more than half of the present peak capacity of the Buckman wellfield, estimated at about 4,000 gpm (Las Campanas, 2000).

This alternative would no doubt involve considerable Las Campanas financial support in rehabilitating and operating the system into the foreseeable future. Use of this alternative for meeting all of Las Campanas' future water needs is probably predicated on either a regional solution and considerable 'new water' being made available from a Rio Grande diversion, (since increasing the capacity of the Buckman system is problematic), or on effluent being provided from the City WWTP for irrigation of the Las Campanas golf course.

One advantage to the alternative is that new rights-of-way for pump stations and conveyance lines would not be needed or would be minimal.

Alternative B – New Wells

Las Campanas could conceivably construct new wells at a nearby location in the Tesuque Formation aquifer and deliver the water via a new pipeline to the development. Based on considerable hydrogeologic knowledge of the area, Pete Balleau of Balleau Groundwater, Inc. (2001) suggested the advantages of locating new wells in Section 32 several miles northeast of Las Campanas. This would minimize (though not eliminate) interference effects on the existing Buckman wells and provide good water quality. Our preliminary estimates are that at least three new wells would be required (assuming 800 to 1,000 gpm capacity) to provide a full Las Campanas supply and provide standby and peaking needs.

Gaining permits from the OSE for such wells will undoubtedly be extremely difficult. Protests and extensive hearings would be entailed. Offsetting the effects on adjacent water rights holders and possibly a large-scale recharge project would be needed as mitigative measures. Such a recharge scheme would be costly and difficult to permit. Consequently, and like the Buckman Wellfield alternative, a New Wells alternative would probably only be viable as part of a regional solution involving new water being made available from the Rio Grande to the City; or with effluent provided from the City WWTP for irrigation of the Las Campanas golf course.

A further disadvantage of this alternative is that new rights-of-way for pump stations and conveyance lines would be needed.

Alternative C – Infiltration Gallery at Buckman

Rationale for Alternative

The Buckman riverfront area in the northern reach of White Rock Canyon (Figure 3-1) is comprised of Quaternary alluvium that has been deposited by the Rio Grande and the ephemeral Canada Ancha Arroyo. Smaller unnamed arroyos discharge to the Rio Grande just north of the Canada Ancha. This alluvium is underlain by the Tesuque Formation.

There have been at least three investigations done in the Buckman riverfront area to determine the water-supply potential. Shomaker (1975) reported on two test borings installed to depths of about 100 feet. Pump tests suggested that the alluvium was permeable, but that the hydraulic connection to the river was not demonstrated. In 1983, the Ranney Method Western Corporation (1983) investigated the Buckman area for its potential for a radial collector (Ranney) well. Ranney concluded that the alluvium in the area investigated had a relatively low permeability and was not particularly well connected hydraulically to the Rio Grande.

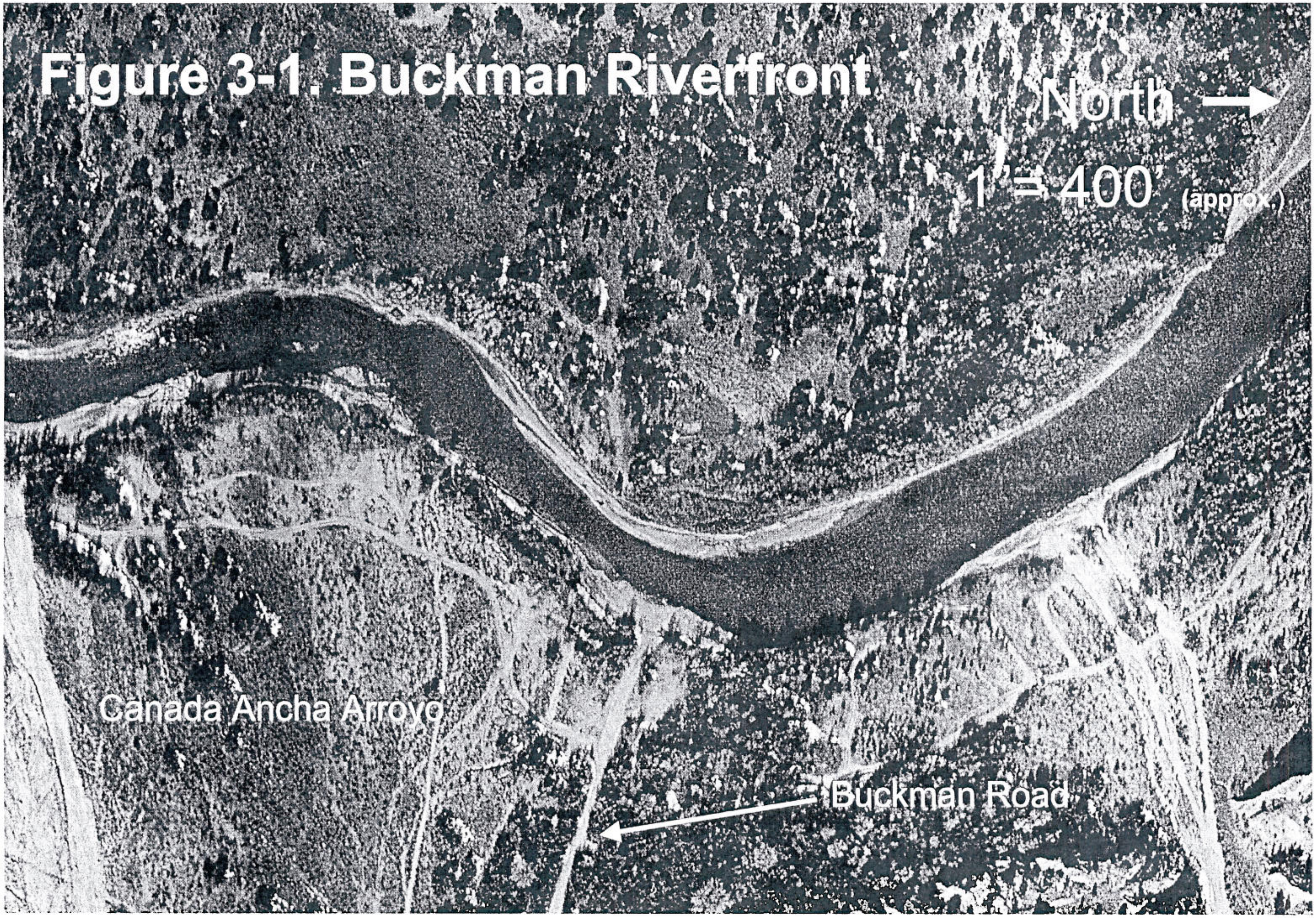


Figure 3-1. Buckman Riverfront

Balleau Groundwater (1995) evaluated the geohydrologic conditions in the alluvium adjacent to the Buckman riverfront for the feasibility of locating an infiltration gallery to provide a water supply for Las Campanas. The investigation, which included 16 test wells installed to depths of 20 to 28 feet, found the presence of an extensive clay deposit underlying alluvium comprised of sand, gravel, cobbles, and boulders. While the test wells indicated a hydraulic connection of the alluvium with the river, the presence of the clay, relatively shallow depth of the alluvium, and the low vertical conductance of the deposits were deemed as limiting to an efficient infiltration gallery. Balleau concluded that a 1,700-foot-long infiltration gallery, 12 feet below the water table and 40 feet east of the riverbank, would yield about 1,800 ac-ft/yr.

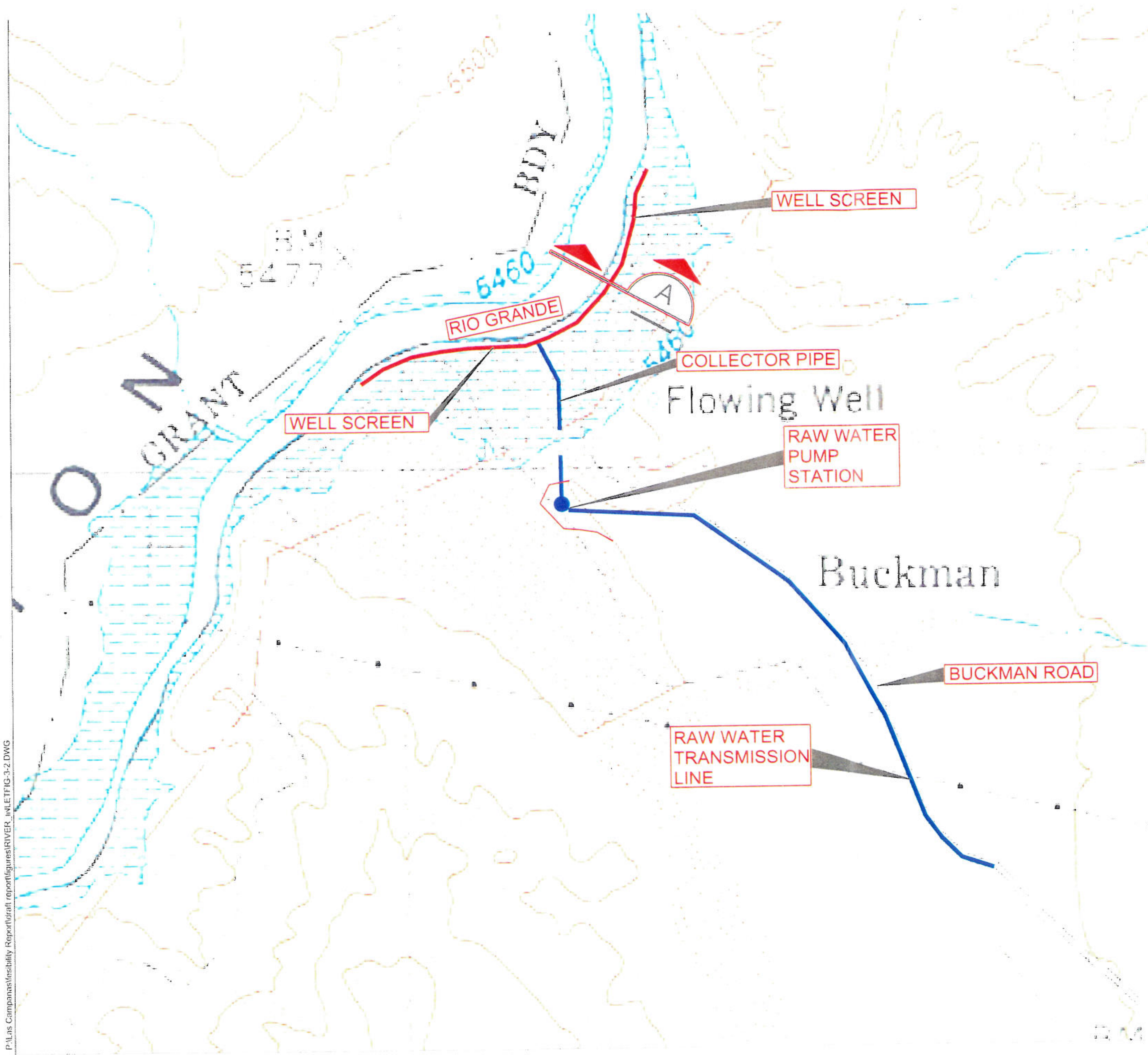
In the course of the present investigation, we reviewed Balleau's 1995 report and concur with its conclusions. Although a yield of 1,800 ac-ft/yr (1.6 mgd or 1,120 gpm) fits Las Campanas' needs on an annual basis, it is inadequate to meeting peak summertime demands that are perhaps twice as high (i.e., 3.2 mgd or 2,240 gpm). Consequently, the infiltration gallery would have to be coupled with an off-peak storage reservoir (preliminary estimate is a minimum of 50 ac-ft or about 16 million gallons [MG]) to be viable. Another issue is the potential for clogging of the infiltration gallery— a common problem with infiltration systems.

Balleau Groundwater (1995) also cautioned about construction difficulties related to the presence of large basalt boulders in the alluvium along the east riverbank at Buckman. These boulders, combined with high water table conditions, would make construction trenching and backfill operations problematic. Moreover, an infiltration gallery could have significant effects on the riparian vegetation along the east bank, both during construction and operation. One positive aspect of an infiltration gallery is that the water, while requiring treatment and disinfection, would be low in turbidity and generally free of river sediment (unlike that produced by direct surface diversion from the river).

Conceptual Layout of Infiltration Gallery Alternative

The preliminary layout of the Infiltration Gallery alternative is shown schematically in Figures 3-2 and 3-3. Facilities would consist of the following:

- 1.6-mgd infiltration gallery (1,700$^{+/-}$ ft of horizontal well screen buried 15 to 20 feet deep) along the east bank of the Rio Grande at Buckman Road
- Collection sump and 1.6-mgd primary pump station to convey water from the infiltration gallery south along Buckman Road to additional booster pump stations
- Three 1.6-mgd booster pump stations along the Buckman Road corridor to convey water up to the Las Campanas development. Each booster pump station would consist of:
  - Three 550-gpm pumps
  - Small aboveground storage reservoir (100,000 to 150,000 gallons) to provide adequate pump suction head, surge protection, and control pump operation
  - Building enclosure (1,000 to 1,200 square feet [ft^2]) to house pumps and associated electrical and control equipment



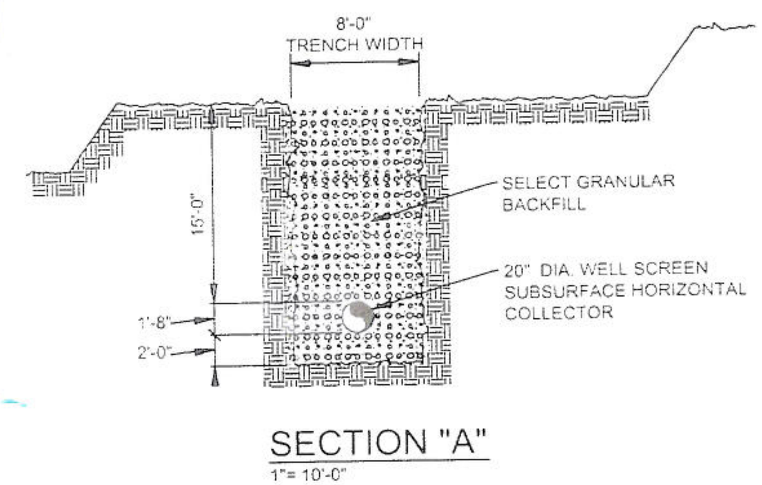


FIGURE 3-2
LAS CAMPANAS WATER PROJECT
INFILTRATION GALLERY AT BUCKMAN RIVER FRONT

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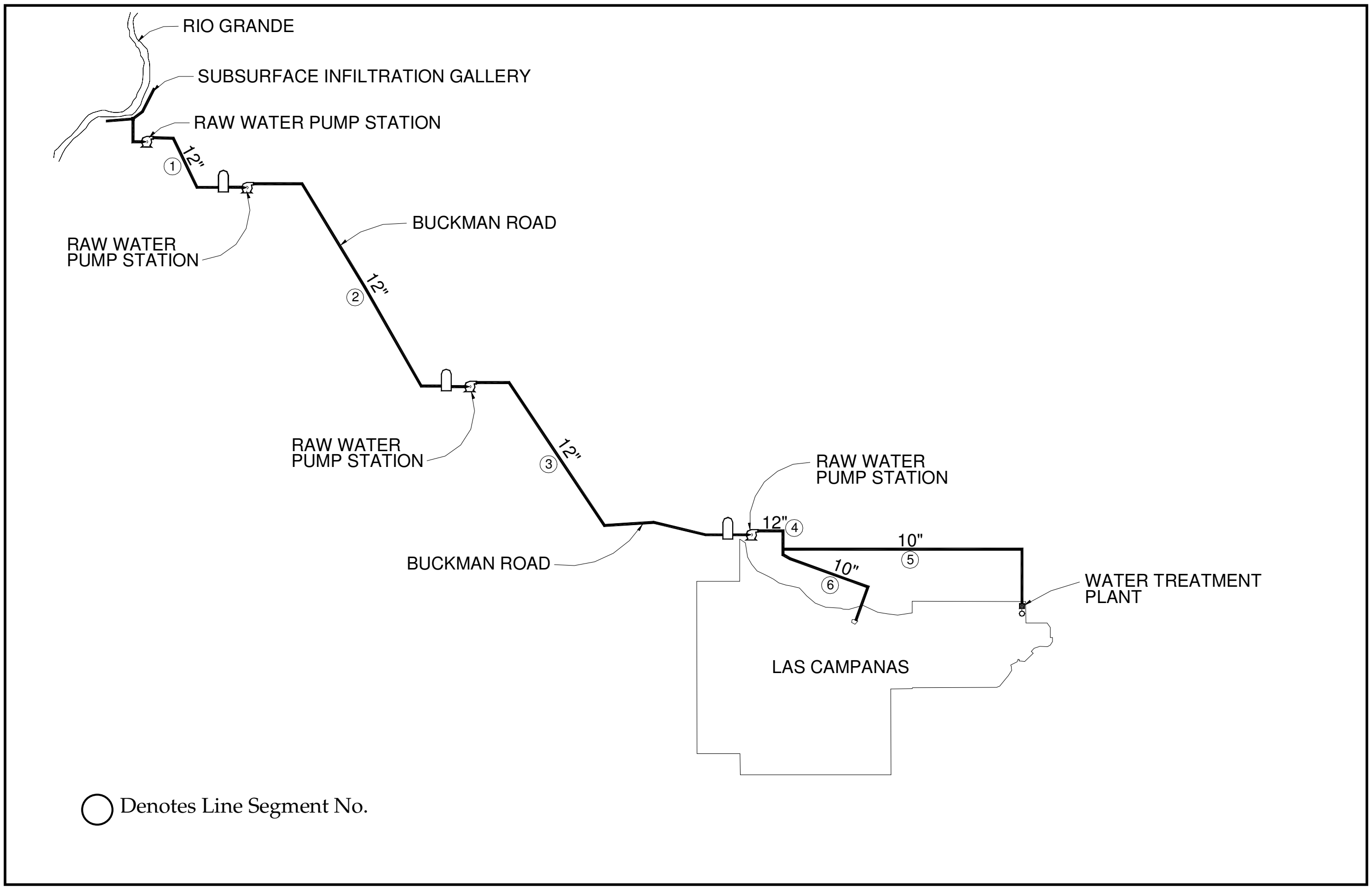


Figure 3-3. Schematic Layout of Infiltration Gallery Alternative

- Approximately 58,650 feet of 12-inch-diameter pipeline
- Approximately 14,085 feet of 10-inch-diameter pipeline
- 50 ac-ft of additional raw water storage at Las Campanas
- 1.0-mgd package water treatment plant at Las Campanas to treat the water for potable demands

Preliminary Cost Estimate

Estimated construction, operation and maintenance, and 20-year present worth costs for the Infiltration Gallery alternative are summarized in Table 3-1 below:

TABLE 3-1
Preliminary Construction Cost Estimate for Infiltration Gallery at Buckman

Line segment	Pipe Length (ft)	Pipe Dia (in)	Roadway Length (ft)	Bore/Jack Length (ft)	Pipe Cost	Valves/Fittings Cost	Road Surfacing Cost	Bore/Jack Cost	Total Cost
1	8850	12	8850		$ 238,950	$ 47,790	$ 125,710	$ -	$ 412,450
2	19250	12	19250		$ 519,750	$ 103,950	$ 273,438	$ -	$ 897,138
3	21550	12	21550		$ 581,850	$ 116,370	$ 296,875	$ -	$ 995,095
4	9000	12	9000		$ 243,000	$ 48,600	$ -	$ -	$ 291,600
5	11235	10	11235		$ 252,788	$ 50,558	$ -	$ -	$ 303,345
6	2850	10	2850		$ 64,125	$ 12,825	$ -	$ -	$ 76,950
Total Pipe Cost					$ 1,900,463	$ 380,093	$ 696,023	$ -	$ 2,976,578
1.61 MGD River Infiltration Gallery/Pump Station No				1	$ 2,538,844				$ 2,538,844
0.15 MG Storage Reservoir No. 1				1	$ 116,190				$ 116,190
1.61 MGD Pump Station No. 2				1	$ 447,310				$ 447,310
0.15 MG Storage Reservoir No. 2				1	$ 116,190				$ 116,190
1.61 MGD Pump Station No. 3				1	$ 447,310				$ 447,310
0.15 MG Storage Reservoir No. 3				1	$ 116,190				$ 116,190
1.61 MGD Pump Station No. 4				1	$ 447,310				$ 447,310
50 ac. ft. Raw Water Storage Pond				1	$ 1,000,000				$ 1,000,000
1.0 MGD Package Treatment Plant				1	$ 1,000,000				$ 1,000,000
Subtotal									$ 9,206,000
Contingency @ 30%									$ 2,761,800
Mobilization/ Bonding/ Insurance			8%	1	$ 957,424				$ 957,400
Total Estimated Construction Cost									$ 12,925,000

Note: The costs presented in Tables 3-1 and 3-2 are for a 'stand-alone' Las Campanas water supply system and do not reflect a pro rata commitment by Las Campanas in the event such facilities become part of a regional water system. Moreover, the preliminary cost estimates presented in this report do not include costs associated with land acquisition, permitting, engineering, contract administration, and other nonconstruction costs. The opinions of cost have been prepared for guidance in project evaluation and for comparative purposes of the several alternatives. The costs are in current day dollars, without allowance for escalation due to uncertain market conditions and project implementation schedules. The final cost of the project and resulting feasibility will depend on actual labor and material costs under competitive market conditions, power costs, actual site conditions, final project scope, and other variable factors at the time the project goes to construction. As a result, the final construction costs will vary from the preliminary estimates presented herein. Because of these factors, project feasibility, cost/benefit ratios, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets. The American Association of Cost Engineers defines this level of cost opinion as one prepared without detailed engineering data with an expected level of accuracy of plus 50 to minus 30 percent based on the project scope as defined at the time the cost opinion was prepared.

Estimated 20-year present work costs for operation and maintenance for the Infiltration Gallery alternative are about $5 million (much of it related to pumping [power costs]). **Consequently, total 20-year present worth costs are about $18 million.**

Alternative D – River Intake at Buckman

Rationale for Alternative

Field investigations by CH2M HILL in January 2001 suggested that a river intake structure located on the east bank of the Buckman riverfront capable of diverting significant amounts (more than 10,000 ac-ft/yr) of water might be viable. This preliminary finding was based on the following:

- The river channel immediately downstream (south) of the terminus of Buckman Road (see Figure 3-1 and Figure A-1, Appendix A) is lined ('armored') with large cobbles and small boulders and located on the outside of a sweeping bend – suggesting bank stability and favorable hydraulic conditions to allow river water to flow into a bankside intake without a dam or other major channel improvements.
- Probing with a calibrated rod indicated that water depths adjacent to the east bank were at least 3 feet at low flow (<500 cfs).
- Review of U. S. Geological Survey (USGS) flow records from the long-term record at the Otowi gaging station 4 miles upstream indicated that:
  - Peak flows on the Rio Grande at Otowi (and at Buckman) have been dramatically reduced by the construction and operation of Abiquiu Reservoir on the Rio Chama since 1963.
  - Because of the operations at Abiquiu Reservoir and the importation of SJC water since about 1971, late summer and fall low flows had been augmented. See Figures A-11 and A-12 in Appendix A for summaries of Rio Grande flow history.

The above factors suggested a location along the east bank of the river that is sufficiently stable for construction of an intake. To further evaluate the stability of the channel, historic maps and aerial photos (obtained from the U. S. Army Corps of Engineers, Albuquerque District, 2001) were obtained and reviewed by CH2M HILL. The series of aerial photos covering the period 1976 to 2001 (see Figures A-5 to A-9 in Appendix A) show that a site just downstream of the Buckman Road terminus has been stable (i.e., has not moved) since at least 1976.

Dr. Richard Heggen, Professor Emeritus of Civil Engineering at UNM and a specialist in fluvial processes and stream hydraulics, conducted an independent assessment of the proposed intake site. Heggen prepared an analysis summarized in the technical memorandum included in Appendix A entitled, *Evaluation of Channel Morphology of the Rio Grande near Buckman, NM*. He concluded that a location some 200 feet downstream of the Buckman Road terminus was likely to be stable, even though there was evidence of a secondary low water channel that cut behind the proposed intake site in the 1940s. The proposed intake site has remained on the primary channel of the Rio Grande on the east bank does not appear to have moved since at least 1947.

Dr. Heggen also prepared a report entitled *Preliminary Las Campanas Intake Sediment Study*. Included in Appendix A, this preliminary report provides an initial analysis of sediment issues related to the operation of the proposed intake and a sedimentation basin located nearby.

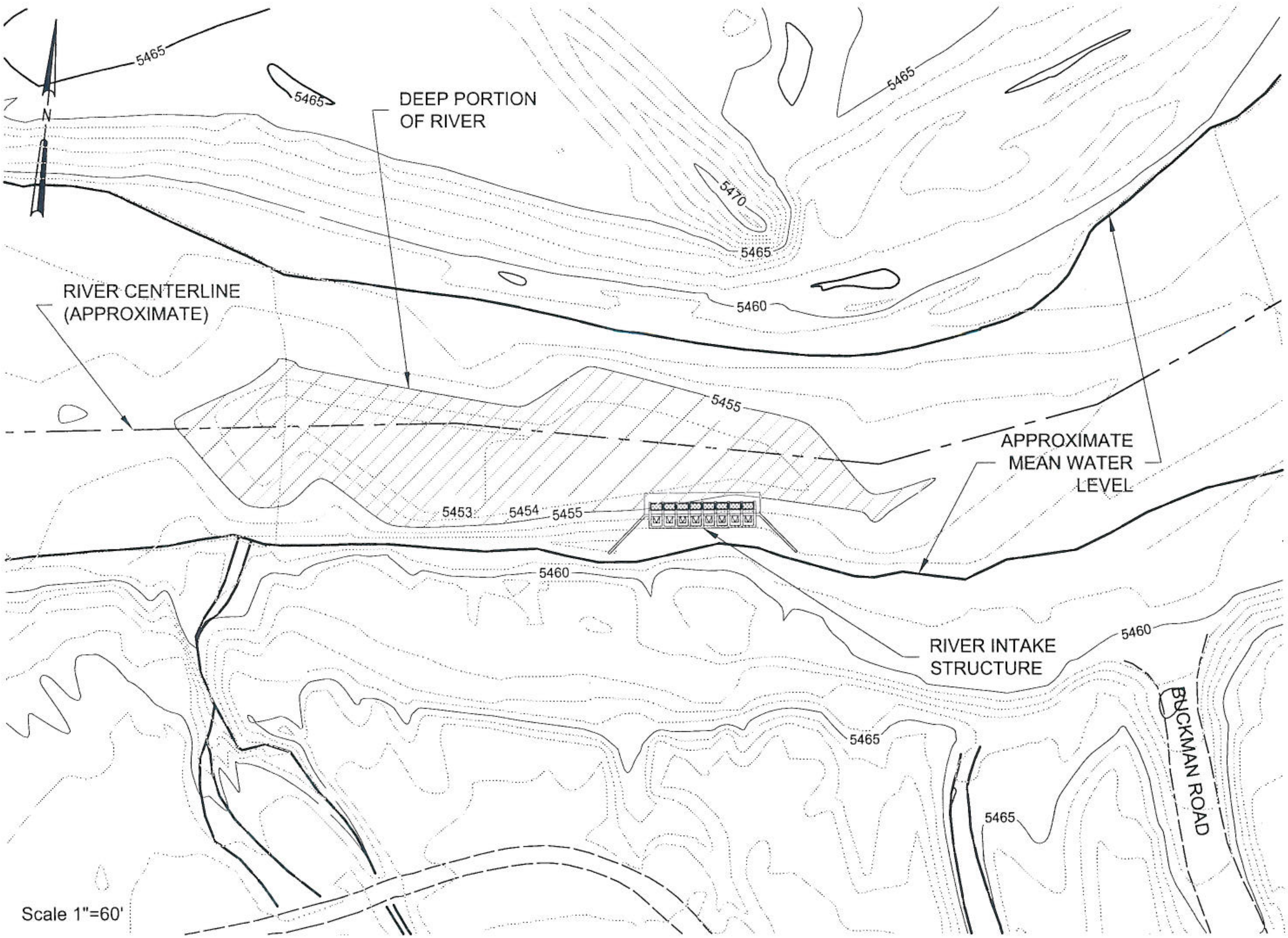
Aerial mapping and channel cross-sections measurements were conducted and as a basis for a detailed topographic map of the Buckman riverfront. As indicated in Figure 3-4, the channel at the proposed intake site is relatively narrow (90 to 100-feet wide) with a water surface at about 5458 feet at mean flow of about 1,500 cfs. A 'scour hole' some 4 to 5-feet deep is present opposite and downstream of the proposed intake location.

Calculations derived from runs on the stream hydraulics model HEC-RAS prepared by Dr. Heggen (2001) indicated that at extreme low flow (200 cfs), elevation of the river water surface at the proposed intake site would be about 5456.8 feet. The channel at the intake site acts somewhat like a Parshall flume, which is generally good for minimizing deposition of material in front of the intake.

For purposes of simulation, we assumed a slope-screened intake at bottom elevation 5454.0 with the top of the screens at about 5456.5 and extending some 15 feet into the channel from the east bank. Comparison of water surface profiles across a range of flows and up to an estimated 100-year peak flow of 17,800 cfs suggested that the intake would not markedly change the hydraulic regime of the river, cause erosion on the opposite bank, allow the river to back-cut behind the intake, etc. Further details on the channel cross sections and intake layout used in the hydraulic evaluation are provided in Appendix B.

While additional channel data and more hydraulic analysis is warranted for final siting and design, it is our opinion that a river intake at the proposed location is feasible. Further, we estimate that such a structure is capable of diverting up to 25 cfs of water at conditions of extreme low river flow (i.e., 200 cfs) and probably more at higher flows. Intake design will have to consider maintenance issues including deposition or rearrangement of bed materials in front of the intake after large floods, partial clogging of intake screens by leaves, algae, etc. (most of which can be addressed by compressed air automated cleaning), and security, safety, and vandalism issues.

The water quality of water diverted from the river by an intake (or infiltration gallery) should be considerably better than groundwater with respect to major ions and total dissolved solids. Comparison of typical river water quality data (see Appendix C, Table C-1) suggests that total dissolved solids of river water is generally in the range of 150 to 250 milligrams per liter (mg/L). This is about half the levels of typical Buckman wellfield water. Suspended sediment in water diverted by a river intake is a significant issue. Figures C-1 and C-2 in Appendix C indicate that suspended sediment concentrations are often above 100 mg/L at mean flow conditions (1,500 cfs). While it is unclear how much suspended sediment would actually pass an intake fish screen (mesh size of 2.0 millimeters [mm]), our preliminary estimates indicate that several tons per day is possible for a diversion ranging from 5 to 25 cfs.



DETAILED CHANNEL TOPOGRAPHY IN VICINITY OF PROPOSED RIVER INTAKE

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FIGURE 3-4

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Conceptual Layout of River Intake Alternative

The River Intake alternative would involve construction of two 3 feet by 5 feet sloped rectangular screens (stainless steel, with approximate 2 mm openings in a parallel mesh arrangement to act at fish screens). Each screen would have a peak capacity of 3.0 to 3.5 cfs. Based on discussions with permitting agencies (USFS, Corps) we have assumed that the intake would be oversized to allow insertion of up to six additional screens to provide for water for the City and County of Santa Fe and possibly Los Alamos County. Again, we estimate the total capacity of such a structure would be about 25 cfs.

The alternative would provide an adequate water supply to meet all of the Las Campanas peak potable and irrigation demands without the need for additional storage capacity for the golf course. The river diversion and raw water pipelines from the river to a sedimentation pond (located less than 1,000 feet east on a terrace overlooking the Canada Ancha), would also be oversized to accommodate additional water for a higher capacity regional system. The sedimentation pond, pumping facilities, and transmission pipelines would be designed and constructed to provide a maximum water supply of 3.2 mgd to meet the peak water demands for Las Campanas. A schematic layout of the facilities required for the River Intake alternative is shown in Figures 3-5 and 3-6.

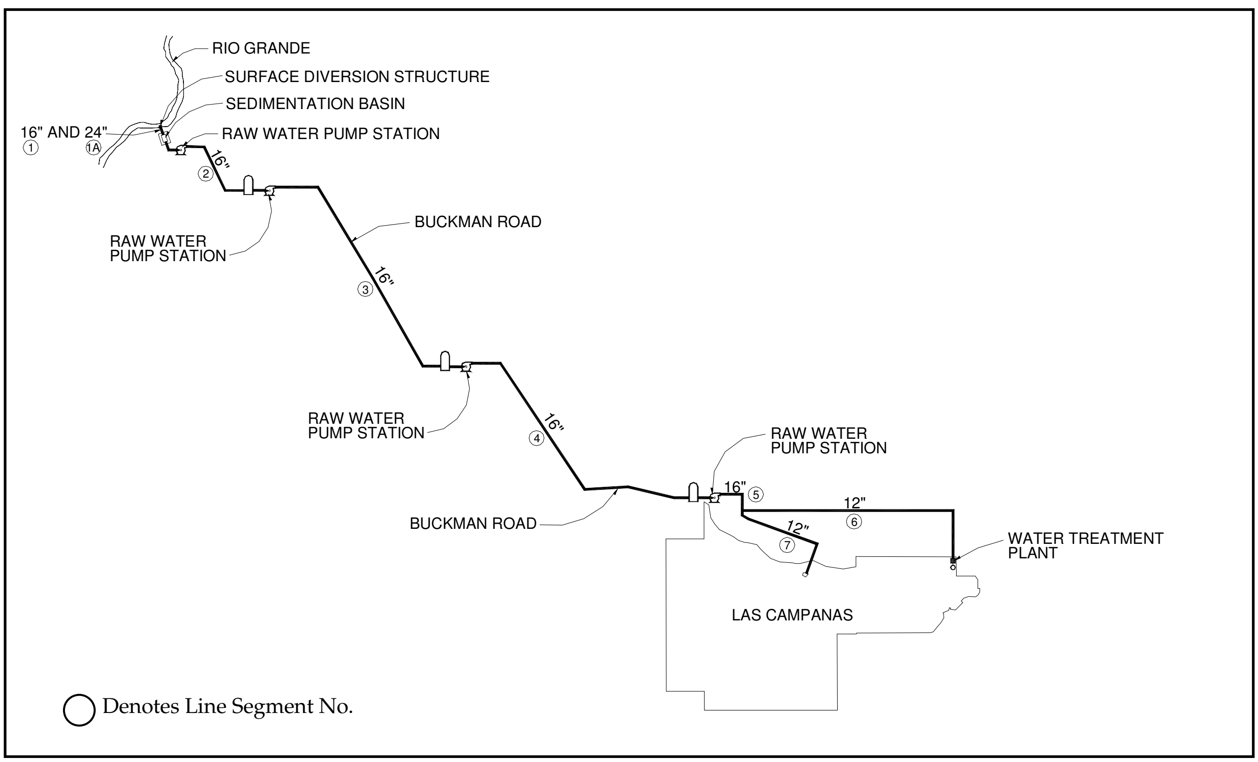


Figure 3-5. Conceptual Layout of River Intake Alternative

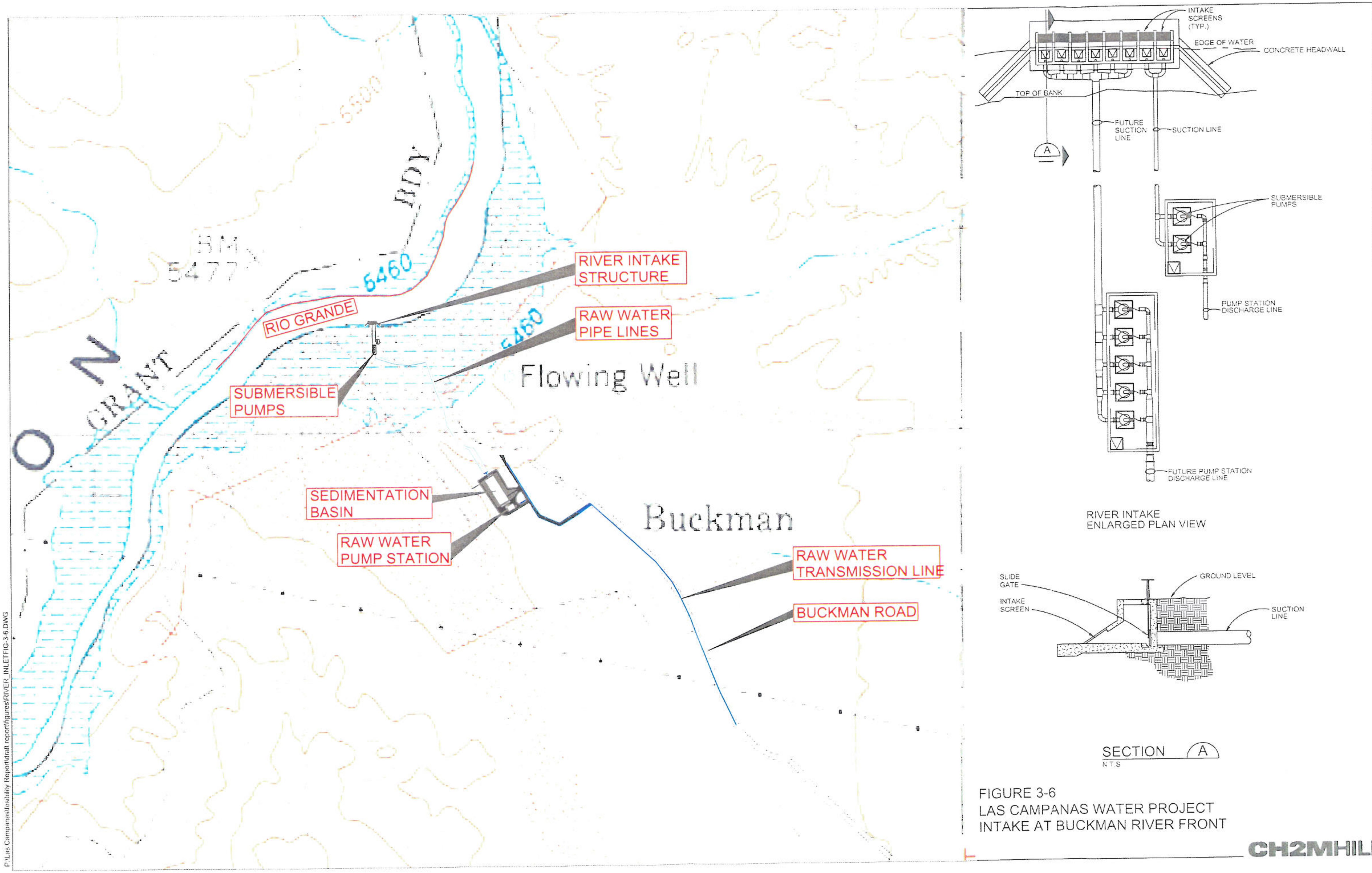


FIGURE 3-6
LAS CAMPANAS WATER PROJECT
INTAKE AT BUCKMAN RIVER FRONT

CH2MHILL

Facilities required for the River Intake Alternative include:

- Sloped-screened river intake structure on the east bank of the Rio Grande at Buckman Road (two screens for Las Campanas, additional six embayments for future screens)
- Two low-head canned submersible pumps to convey up to 3.2 mgd of raw water (for Las Campanas only) from the river intake to sedimentation ponds located approximately 1,000 feet east of the riverbank along Buckman Road
- Sedimentation pond approximately 0.25 to 0.50 acres in size to remove much of the sediment load prior to pumping raw water up the supply pipeline
- Four 3.2-mgd booster pump station facilities along Buckman Road to convey water from the sedimentation pond up to Las Campanas development. Each pump station facility would consist of:
  - Three 1,100-gpm booster pumps
  - Small aboveground storage reservoir (100,000 to 150,000 gallons) to provide adequate pump suction head, surge protection, and control pump operation
  - Building enclosure (1,000 to 1,200 ft^2) to house pumps, associated electrical and control equipment, and compressor for air cleaning of intake screens (this facility could also be located closer to the intake, depending on final design)
- Approximately 600 feet of 16-inch-diameter pipeline from diversion to sedimentation pond for Las Campanas water
- Approximately 600 feet of 24-inch-diameter pipeline from diversion to sedimentation pond for future City/County connection
- Approximately 58,650 feet of 16-inch-diameter pipeline
- Approximately 14,085 feet of 12-inch-diameter pipeline
- 1.5-mgd packaged water treatment plant at Las Campanas to treat the water for potable demands

Preliminary Cost Estimate

Estimated construction, operation and maintenance, and 20-year present worth costs for the River Intake alternative are summarized in Table 3-2 below. Estimated 20-year present work costs for operation and maintenance for the River Intake alternative are about $5 million (much of it related to pumping [power costs]). **Consequently, total 20-year present worth costs are about $18 million. This is essentially identical to estimated costs for the Infiltration Gallery Alternative.**

TABLE 3-2
Preliminary Cost Estimate for River Intake Alternative

Line segment	Pipe Length (ft)	Pipe Dia (in)	Roadway Length (ft)	Bore/Jack Length (ft)	Pipe Cost	Valves/Fittings Cost	Road Surfacing Cost	Bore/Jack Cost	Total Cost
1	600	16	600		$ 26,400	$ 5,280	$ 8,523	$ -	$ 40,203
1A	600	24	600		$ 39,600	$ 7,920	$ 8,523	$ -	$ 56,043
2	8250	16	8250		$ 363,000	$ 72,600	$ 117,188	$ -	$ 552,788
3	19250	16	19250		$ 847,000	$ 169,400	$ 273,438	$ -	$ 1,289,838
4	21550	16	21550		$ 948,200	$ 189,640	$ 296,875	$ -	$ 1,434,715
5	9000	16	9000		$ 396,000	$ 79,200	$ -	$ -	$ 475,200
6	11235	12	11235		$ 370,755	$ 74,151	$ -	$ -	$ 444,906
7	2850	12	2850		$ 76,950	$ 15,390	$ -	$ -	$ 92,340
Total Pipe Cost					$ 3,067,905	$ 613,581	$ 704,545	$ -	$ 4,386,031
13.21 MGD River Intake				1	$ 810,104				$ 810,104
Sedimentation Pond				1	$ 195,190				$ 195,190
3.21 MGD Pump Station No. 1				1	$ 457,410				$ 457,410
0.15 MG Storage Reservoir No. 1				1	$ 116,190				$ 116,190
3.21 MGD Pump Station No. 2				1	$ 457,410				$ 457,410
0.15 MG Storage Reservoir No. 2				1	$ 116,190				$ 116,190
3.210 MGD Pump Station No. 3				1	$ 457,410				$ 457,410
0.15 MG Storage Reservoir No. 3				1	$ 116,190				$ 116,190
3.21 MGD Pump Station No. 4				1	$ 457,410				$ 457,410
1.5 MGD Package Treatment Plant				1	$ 1,350,000				$ 1,350,000
Subtotal									$ 8,920,000
Contingency @ 30%									$ 2,676,000
Mobilization/ Bonding/ Insurance			8%	1	$ 927,680				$ 927,700
Total Estimated Construction Cost									$ 12,524,000

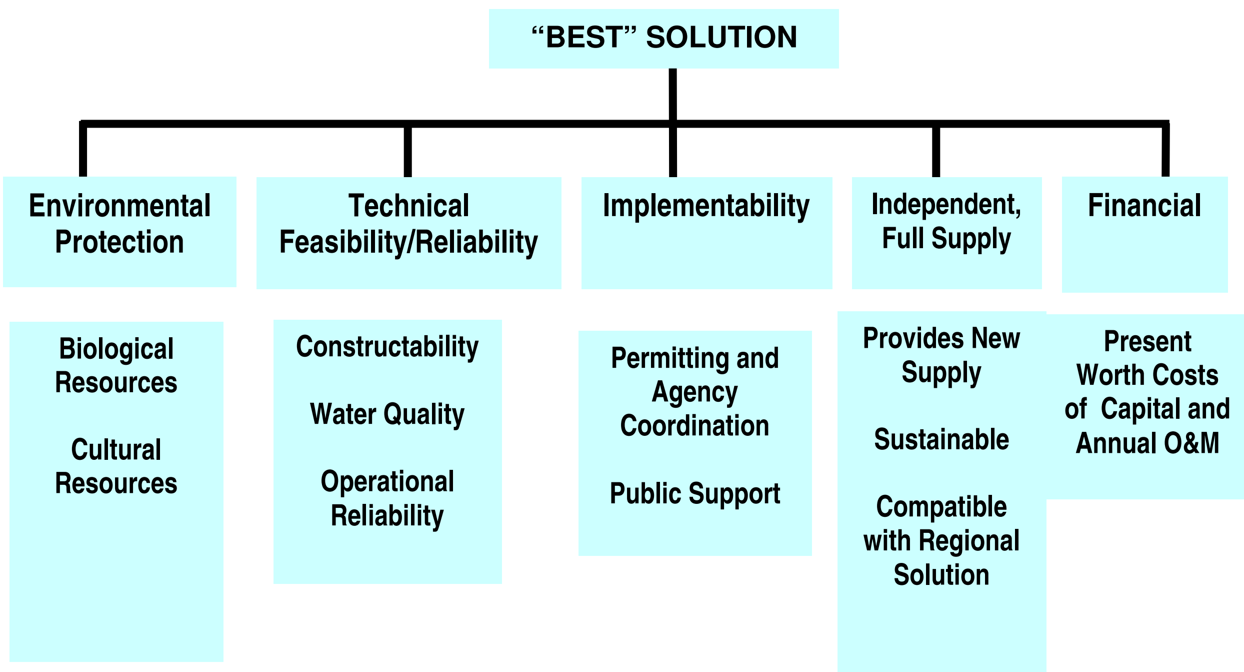
Section 4.
Screening of Water Supply Alternatives

Section 4

Screening of Alternatives and Selection of Preferred Alternative

Screening Criteria

As a basis for screening of water supply alternatives for Las Campanas and selection of a preferred alternative, five major criteria and several subcriteria (most of which have been used by CH2M HILL in recent water supply evaluations for the City's of Albuquerque and El Paso) were identified as relevant. These are as follows:



Environmental Protection

The evaluation of impacts on the environment, including both temporary (e.g., construction-related) and long-term operational impacts, are key considerations in the selection of a "best solution" alternative. Environmental issues of most concern are likely to be the following:

Biological Resources

- Threatened and endangered species – particularly fishes, mammals, birds, and rare plant species
- Wetlands and streamside riparian areas (including arroyos)
- Rangeland vegetation – the BLM, in particular, is concerned about destruction of pinyon-juniper and possible effects on several species of grasses and cactus along proposed pipeline routes

Cultural Resources

- Historical artifacts and ruins, including; for example, the old Buckman town site or native American artifacts/ruins

The screening done in the study for Environmental Protection issues was based on cursory review of limited environmental assessment work done previously by the Sangre de Cristo Water Company in relation to obtaining special use permits in the Buckman area, review of Santa Fe County and State species lists, and brief discussions with USFS, BLM, and State Game and Fish personnel.

In general, our initial conclusions are that the New Wells or Buckman Wellfield alternatives would be the least disruptive and that the Infiltration Gallery alternative (because of extensive construction and long-term water table impacts) could be the most disruptive overall. Use of the Buckman Road instead of a new cross-country pipeline right-of-way should help to minimize BLM concerns about impacts to rangeland vegetation under either the River Intake or Infiltration Gallery alternatives.

Technical Feasibility/Reliability

The technical feasibility/reliability criterion is measured by the ability of an alternative to meet the engineering requirements to reliably divert and convey water from the source of supply to Las Campanas. Subcriteria used in the screening evaluation for technical feasibility/reliability were as follows:

Constructability

Standard construction means and methods are preferred. Alternatives that require specialized construction techniques or extensive temporary controls potentially add a level of complexity, cost, and/or time to the project with little or no added value and, therefore, are less preferred.

For example, alternatives that require the construction of pump stations and pipelines in locations with limited access (e.g., entirely new rights-of-way for new wells) are less desirable than those that utilize existing utility or transportation corridors (e.g., Buckman wellfield). An alternative requiring extensive dewatering or sheetpile work for construction (e.g., Infiltration Gallery and the River Intake) is more difficult than those involving standard well construction techniques.

Water Quality

The quality of the water for the four potential alternatives should be acceptable for all potable and irrigation uses, although well water will likely require no treatment (other than disinfection) whereas the Infiltration Gallery and River Intake alternatives will require full water treatment. Of the latter two, the Infiltration Gallery should provide better raw water quality (e.g., lower turbidity) and somewhat less treatment to meet potable water standards. The chemical water quality of the river diversion alternatives will be somewhat better than the groundwater alternatives since the Rio Grande is a more dilute water than the groundwater in the Tesuque Formation aquifer.

Operational Reliability

Operational reliability is important to the long-term dependability of project facilities. Alternatives with facilities that are easier to operate and maintain (e.g., River Intake) are more desirable than alternatives that are less reliable, or more difficult to operate or maintain (e.g., Infiltration Gallery).

Similarly, alternatives with conveyance systems having fewer pump stations and shorter pipelines (e.g., Buckman Wellfield) are more desirable than alternatives with numerous pump stations or longer conveyance routes.

Implementability

Implementability involves the relative effort required to address various legal, regulatory, and political issues that must be overcome to obtain regulatory permits and gain cooperation and support for a given alternative. Subcriteria considered for assessing Implementability criterion are discussed below.

Permitting and Agency Cooperation

The Infiltration Gallery and River Intake alternatives involve construction and operation within the Rio Grande riverfront and associated floodplain, riparian areas, and the pipeline right-of-way across rolling pinyon-juniper terrain between Buckman and Las Campanas. These lands are under the control of the USFS and the BLM. The Corps also has jurisdiction on the river by virtue of the '404' permitting program. The Buckman Wellfield and New Wells alternatives also entail new construction and crossings of arroyos under the Corps '404' jurisdiction. The OSE will be involved in diversion and water rights permitting for any of the four alternatives. Consultation with the U.S. Fish and Wildlife Service and the New Mexico Game and Fish will also be involved.

In summary, a host of regulatory and resource agencies have an interest and/or voice in defining the Implementability of each alternative. While the difficulty in obtaining permits can be evaluated somewhat objectively based on regulations and past experience, the likelihood of agency cooperation is a considerably more subjective judgment. We have concluded that the likelihood of permitting and agency support will be less for the groundwater alternatives because of the conflicts with existing water rights holders.

Public Support

The public support criterion is intended to reflect the likely level of public acceptance and support for a given alternative. As such, it is less objective than a measure based on permitting and agency coordination issues. Because the various alternatives cannot be 'put to a vote,' assessment of public support for a given alternative must by necessity be based on informed perceptions and judgments.

In developing rankings for public support, considerable reliance was placed on our discussions with governmental officials in the Santa Fe area, local agency officials and persons involved with various interest groups (e.g., environmental organizations). Overall, it is believed that the public would be inclined to be somewhat less for a groundwater alternative than for a river-based alternative — primarily because of the previously mentioned water rights problems.

Independent, Full Supply

An independent, full supply for Las Campanas is important to assure the long-term viability of the development. To the extent possible, the supply should be independent of existing supplies, which as mentioned previously are generally overtaxed and inadequate for the Santa Fe region. A full supply for Las Campanas must be capable of delivering an annual average of 1,800 ac-ft/yr (1.6 mgd or 1,100 gpm) and at a rate of about 3.2 mgd (or 2,200 gpm) during peak-demand summer days.

Provides New Supply

Neither the Buckman Wellfield nor New Well alternatives will provide a new supply of water, and thus, are not independent supplies. Either the Infiltration Gallery or River Intake alternatives would provide an independent, new supply, though the former would not meet peaking requirements without an added storage reservoir at Las Campanas.

Sustainable

The Infiltration Gallery and River Intake alternatives are considered to be sustainable since water would be derived from a renewable surface source, the Rio Grande. The groundwater alternatives, may or may not be sustainable, depending on whether they are coupled with a regional solution that brings a new supply into the Santa Fe area.

Compatible with Regional Solution

The River Intake alternative would appear to have the best chance to be compatible with a regional solution since it has the greatest potential for high yield (>10,000 ac-ft/yr). The low yield and potential for 'blocking' the Buckman riverfront area for others tend to make the Infiltration Gallery less likely to be an advantage to the regional water situation. Either of the groundwater alternatives is also less likely to be a part of a final regional solution.

Financial Considerations

As used in this evaluation, the financial criterion is simply an overall cost ranking of each of the four alternatives based on the estimated present worth costs as follows:

- Present Worth Costs—include capital, operation and maintenance (O&M), and estimated potential mitigation costs
- Capital Costs—cost of all facilities-related construction, including engineering design and rights-of-way in 2001 dollars

- O&M Costs—annual costs to operate and maintain facilities for 20 years, summed as present worth using a 6 percent discount rate

Because of the many unknowns involved with the Buckman Wellfield or New Wells alternatives, estimated 20-year present worth costs were developed only for the River Intake and Infiltration Gallery alternatives (see previous section). For purposes of comparison, we assumed that the two groundwater alternatives would be of about equal cost and somewhat less in cost than the river-related diversion alternatives.

Numerical Ranking of Alternatives

The following simple ranking scheme was used to assign numerical rankings for criteria under each alternative. Numbers were assigned based on judgements of project staff and applied to the four Las Campanas alternatives and as summarized in Table 4-1.

Score	Designation
5	Clearly most favorable as compared to the other alternatives
4	Slightly more favorable as compared to the other alternatives
3	About average (neutral) as compared to the other alternatives
2	Slightly less favorable as compared to the other alternatives
1	Less favorable as compared to the other alternatives

The River Intake alternative was rated highest at 33, followed by Buckman Wellfield (29), New Wells (26), and the Infiltration Gallery (25). Probably the determining factor in the ranking was that the River Intake was the only one of the four alternatives that provided for an independent, full supply for Las Campanas and had the potential to add significant amounts of new water to a regional water supply solution. In terms of overall costs and environmental impacts, staying on the Buckman Wellfield has many advantages for Las Campanas. However, because of the limited capacity of the Buckman Wellfield this alternative is viable only if part of a regional plan that allows replacement of the lost capacity dedicated to Las Campanas with additional regional supplies – for example, the City's proposed use of Ranney collector wells in the Otowi area.

TABLE 4-1
Numerical Ranking of Las Campanas Water Supply Alternatives
General Screening Criteria

Criteria	Subcriteria	A	B	C	D
Environmental Protection					
	Biological Resources	5	4	2	3
	Cultural Resources	5	4	3	4
Technical Feasibility/Reliability					
	Constructability	4	3	2	3
	Water Quality	3	3	3	3
	Operational Reliability	2	2	2	4
Implementability					
	Permitting and Agency Coordination	2	2	3	4
	Public Support	3	3	4	4
Compatibility with Regional Solution		1	1	3	5
Financial Consideration					
	Present Worth Costs	4	4	3	3
	TOTALS	29	26	25	33

Notes:
A Buckman Wellfield – remain on the City's Buckman well system.
B. New Wells – construct new wells (at least two, and possibly three) in the nearby Tesuque Formation Aquifer.
C. Infiltration Gallery – construct infiltration gallery (approximately 1,700 feet)parallel to the Rio Grande at Buckman.
D. River Intake – construct new screened intake structure of the east bank of the Rio Grande at Buckman. Intake sized to accommodate future connection by City and County of Santa Fe

Preferred Alternative

In summary, based on the information and results developed in this report, CH2M HILL recommends the River Intake at the Buckman riverfront as the preferred alternative for a long-range, reliable supply for Las Campanas. The River Intake appears to offer several important advantages:

- A 'stand-alone' alternative capable of independence from existing supplies
- Capable of good response to seasonal peak water demand requirements at Las Campanas
- Relatively minor impacts on the hydrologic or environmental resources of the Rio Grande at Buckman

Conceptual design drawings for the River Intake alternative are provided in Appendix D, Figures D-1 to D-12.

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Appendix A.
Hydrology, Morphology, and Sedimentation of Rio Grande in the Buckman Area

Hydrology of Rio Grande in the Buckman Area

Figure A-1

Rio Grande River at Buckman 1-24-01

1- Rio Grande looking upstream (North) from Buckman Road terminus

2- Rio Grande looking downstream (South) from Buckman Road terminus

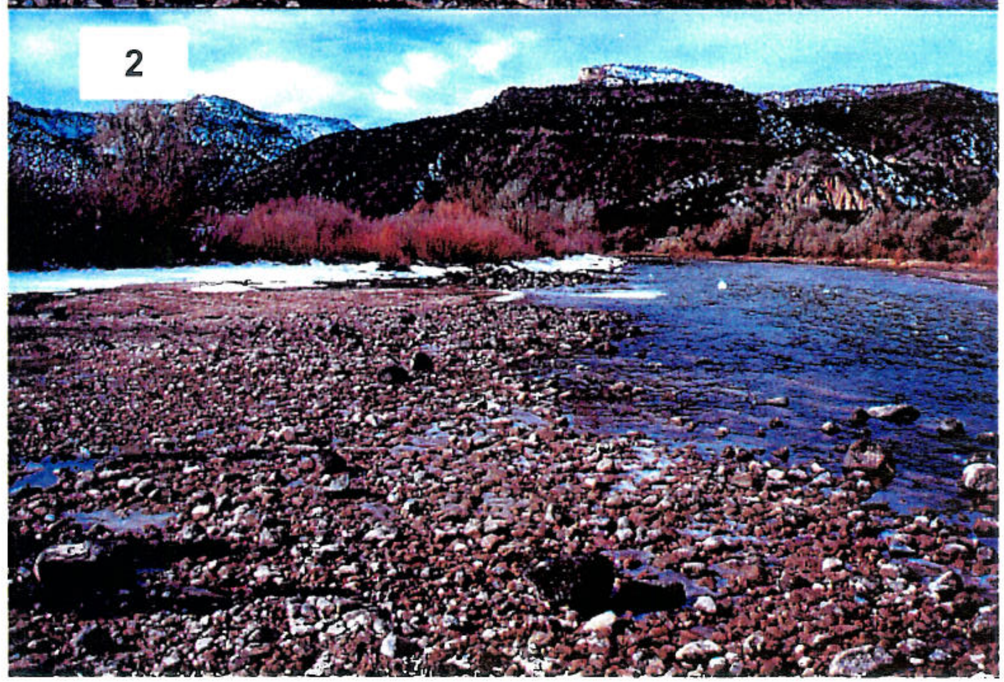
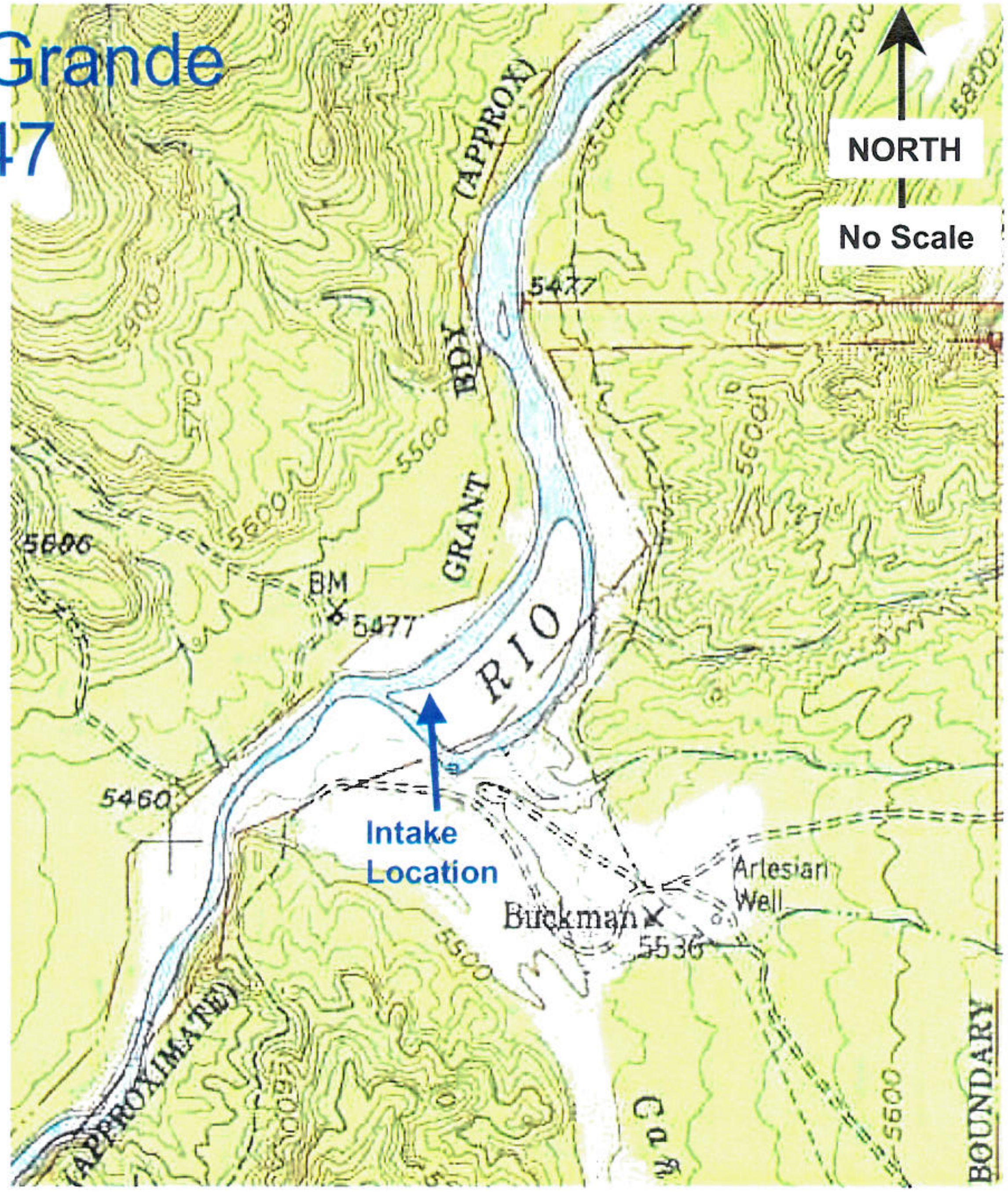


Figure A-2. Rio Grande at Buckman, 1947

Source: USGS 7.5' Map, White Rock, N.M. (1952)

Map from 1947 aerial.



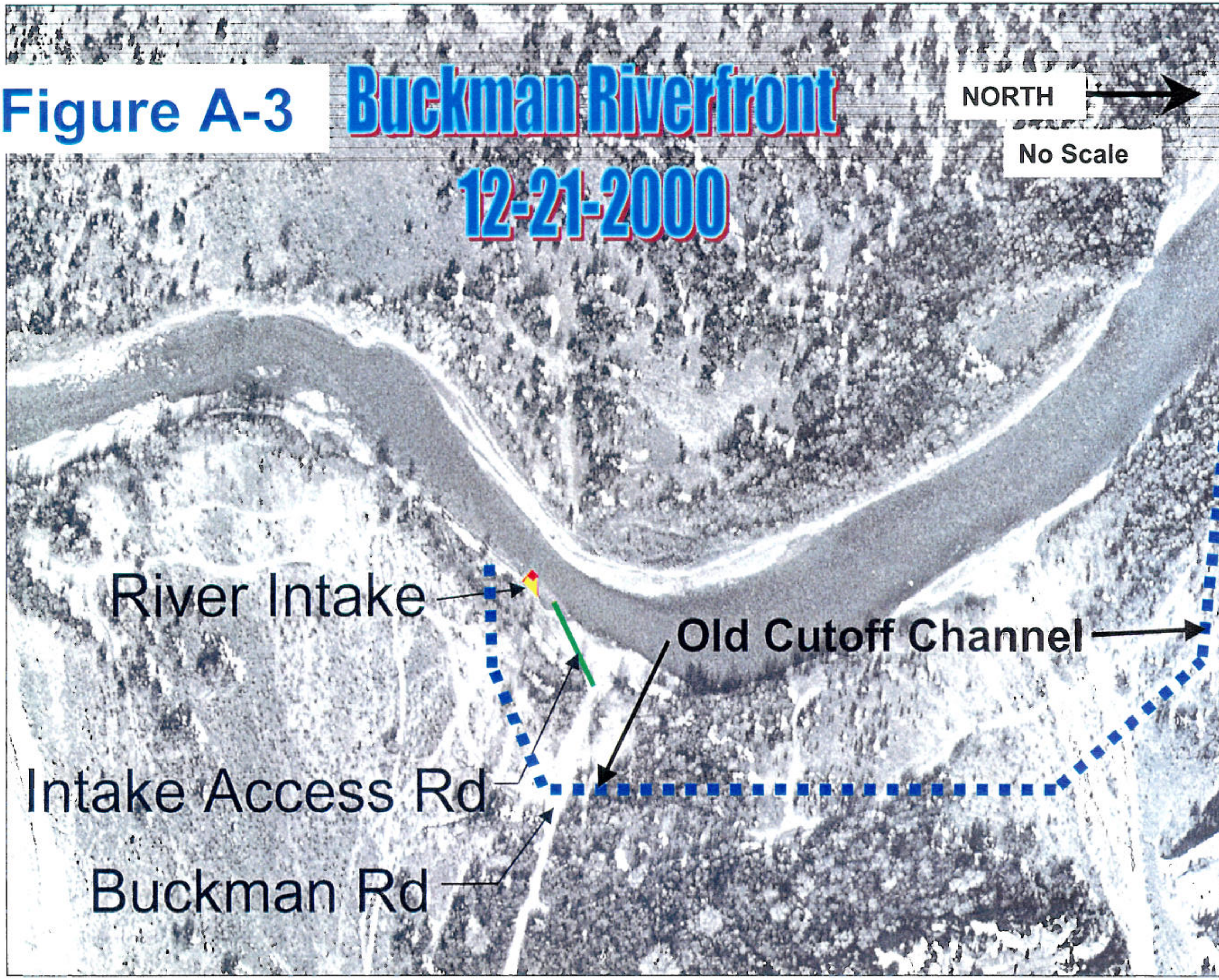


Figure A-3
Buckman Riverfront
12-21-2000
NORTH
No Scale
River Intake
Old Cutoff Channel
Intake Access Rd
Buckman Rd

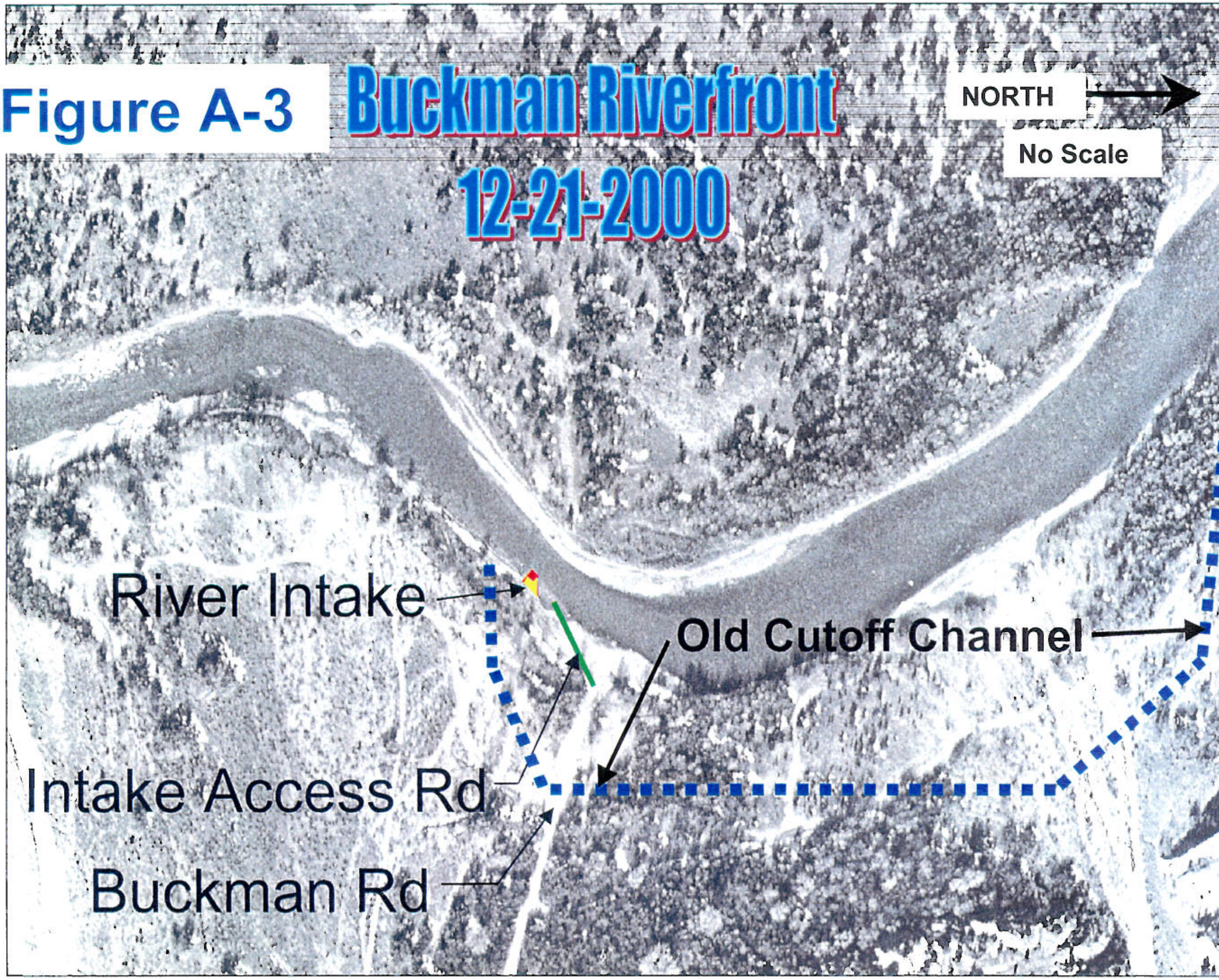
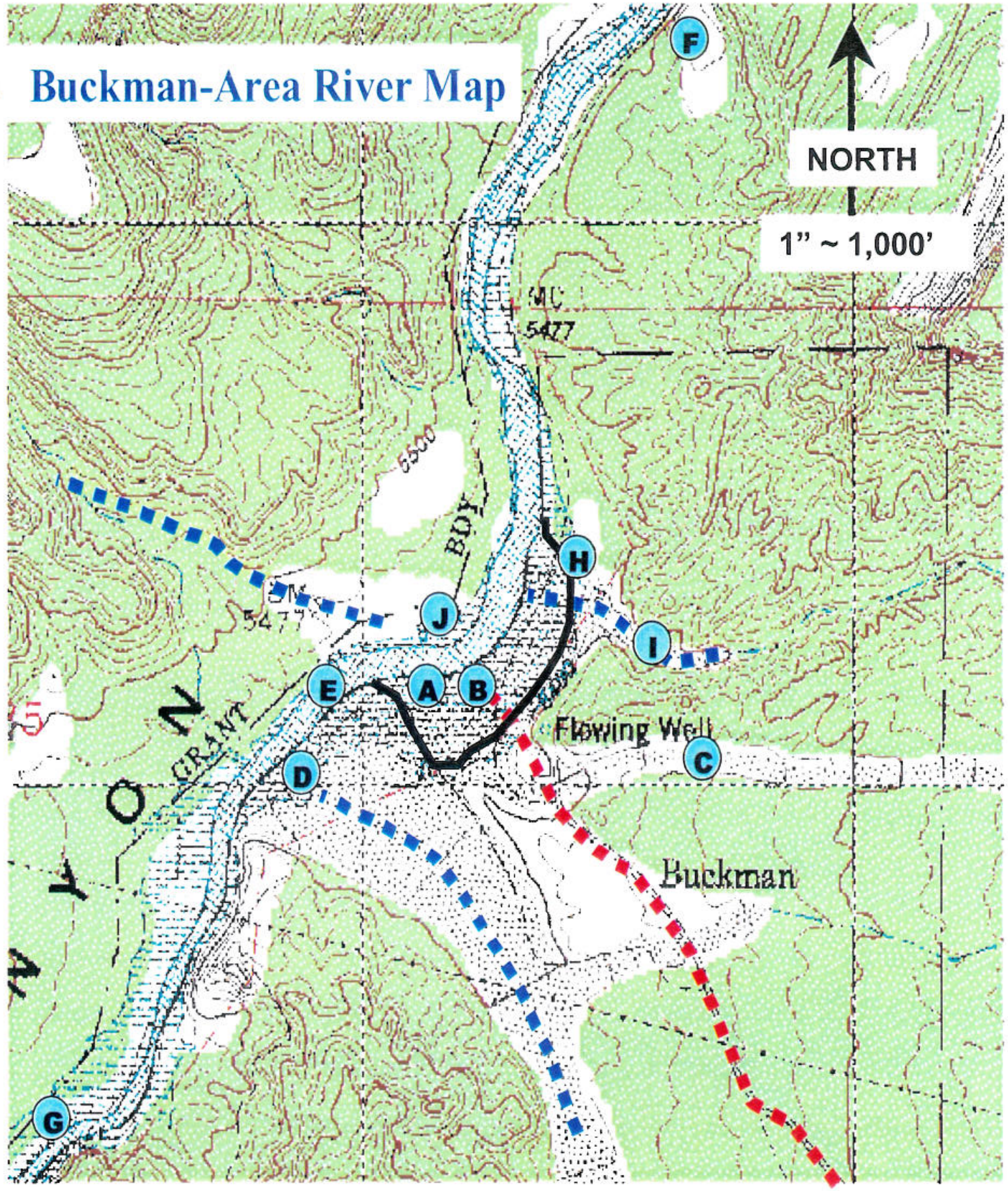


Figure A-3
Buckman Riverfront
12-21-2000
NORTH
No Scale
River Intake
Old Cutoff Channel
Intake Access Rd
Buckman Rd

Figure A-4 Buckman-Area River Map



A- Proposed Intake Site
B- Buckman Road
C, I - Eastside Arroyos
D- Canada Ancha Arroyo
E- Old Buckman Bridge
F - North River Canyon
G- South River Canyon
H, J - Historic River 'Islands' and Cutoffs

Source: USGS 7.5' Map, White Rock, N.M. (1984)

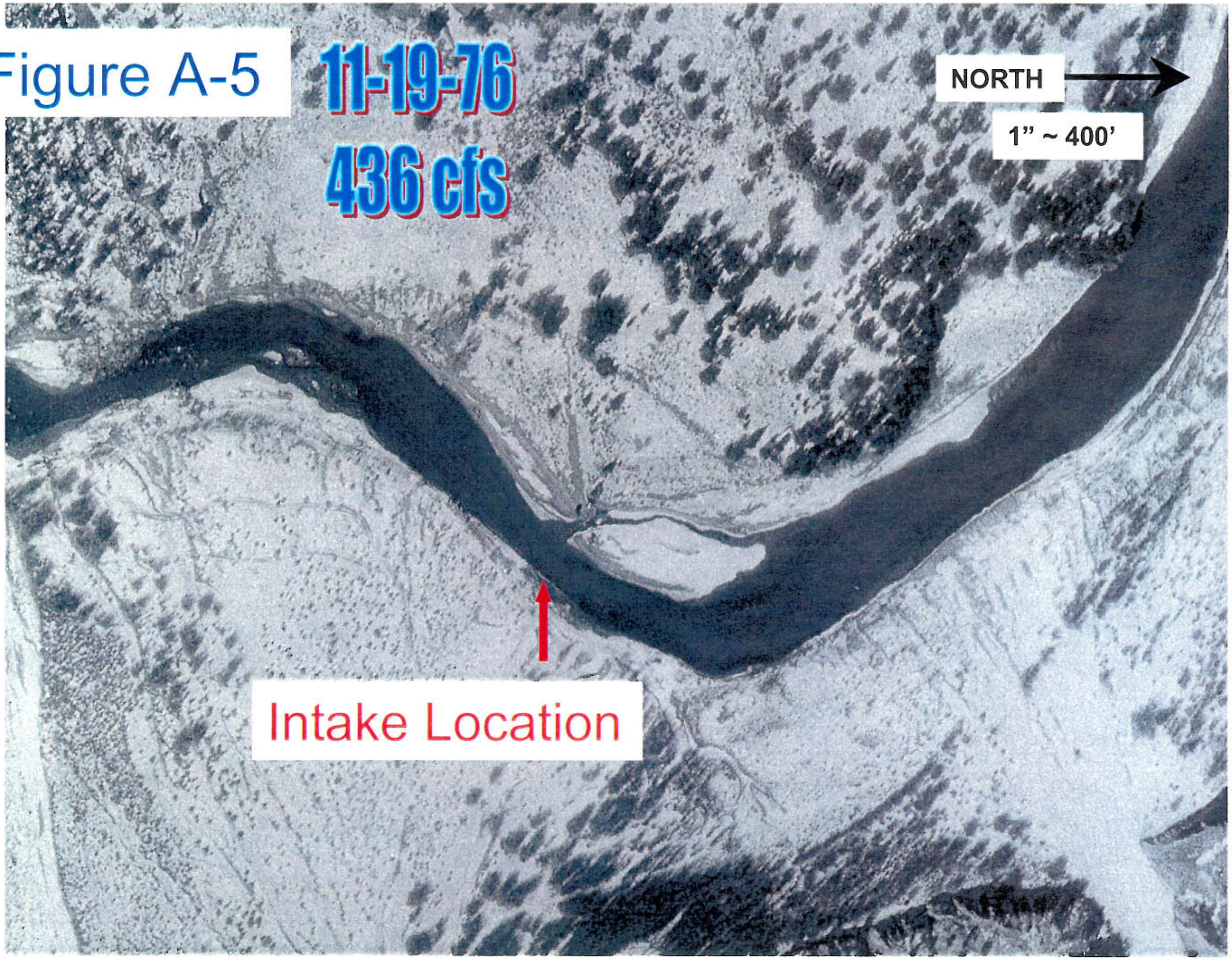


Figure A-5
11-19-76
436 cfs
NORTH
1" ~ 400'
Intake Location

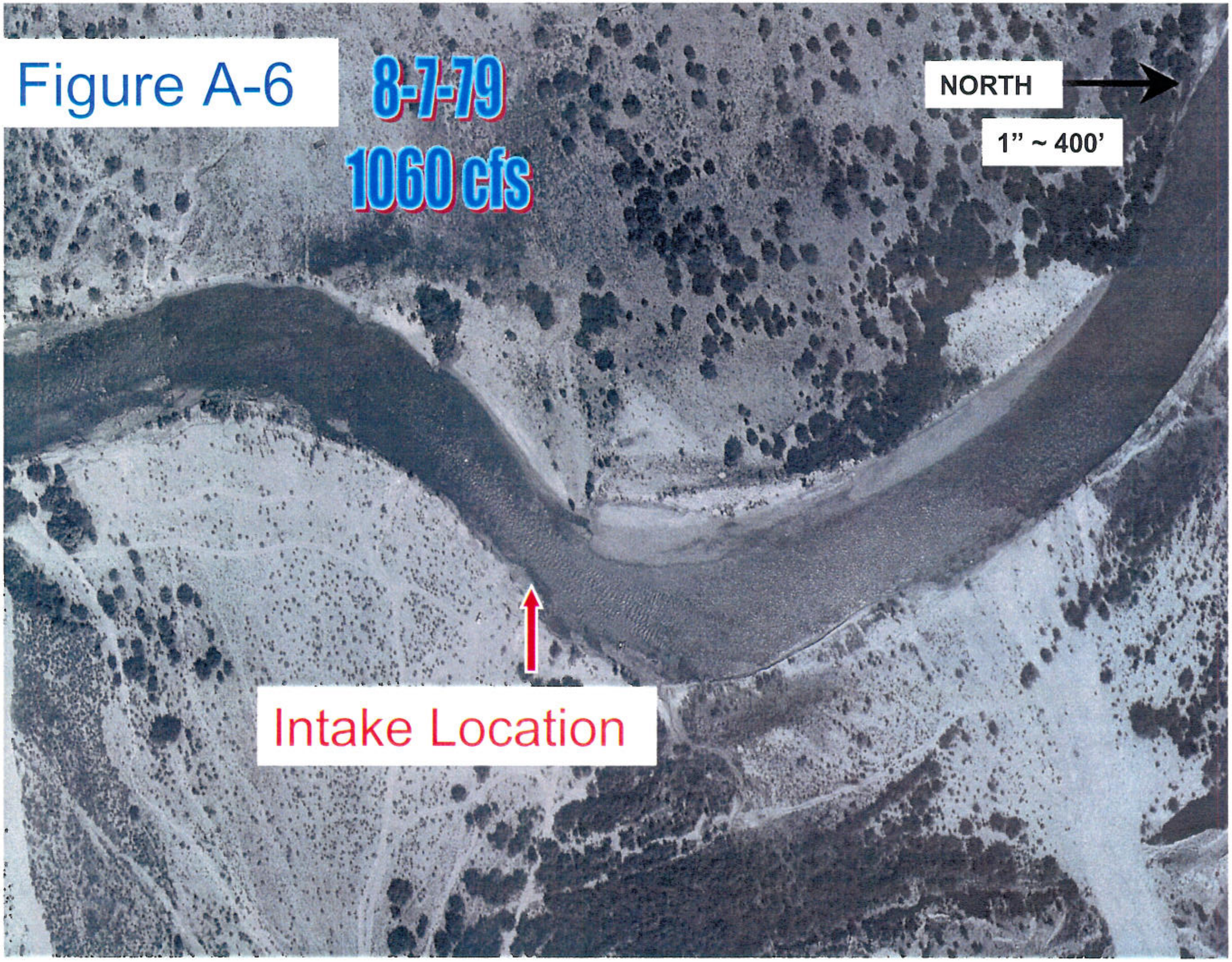


Figure A-6
8-7-79
1060 cfs
NORTH
1" ~ 400'
Intake Location

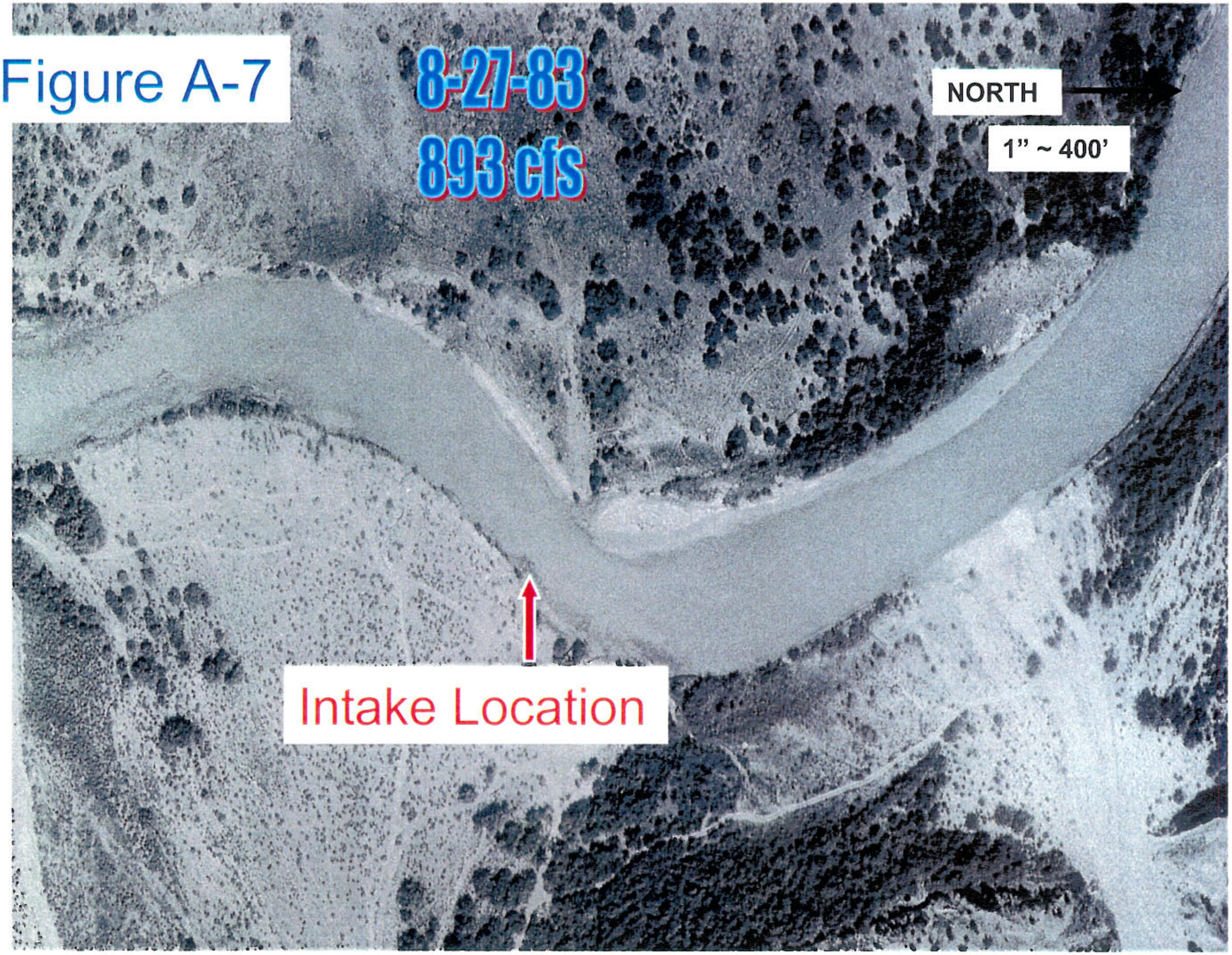


Figure A-7
8-27-83
893 cfs
NORTH
1" ~ 400'
Intake Location

Figure A-8

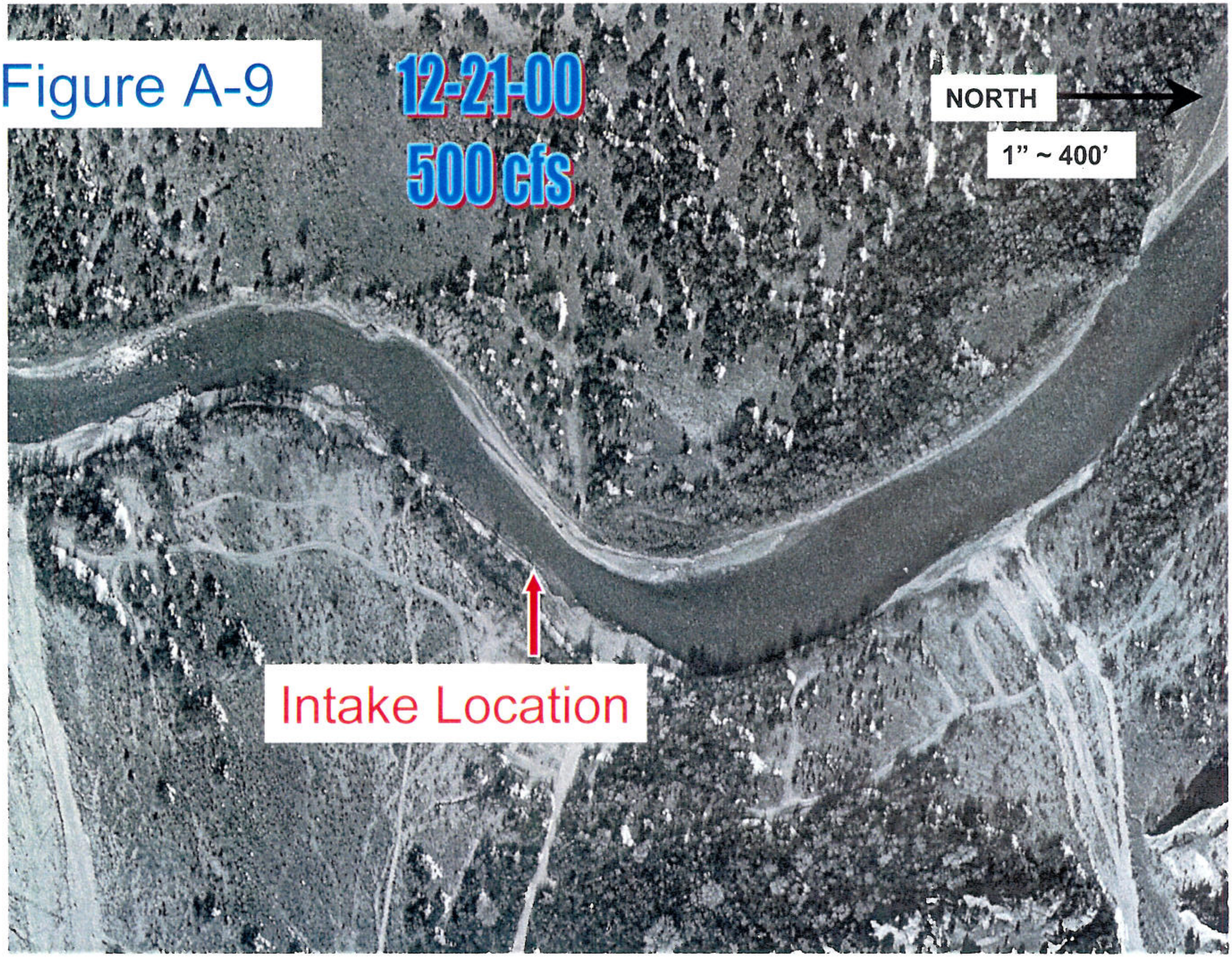


Figure A-9

Figure A-10

Figure A-11 Mean Monthly Flow at Otowi 1900-1962 and 1963-1999

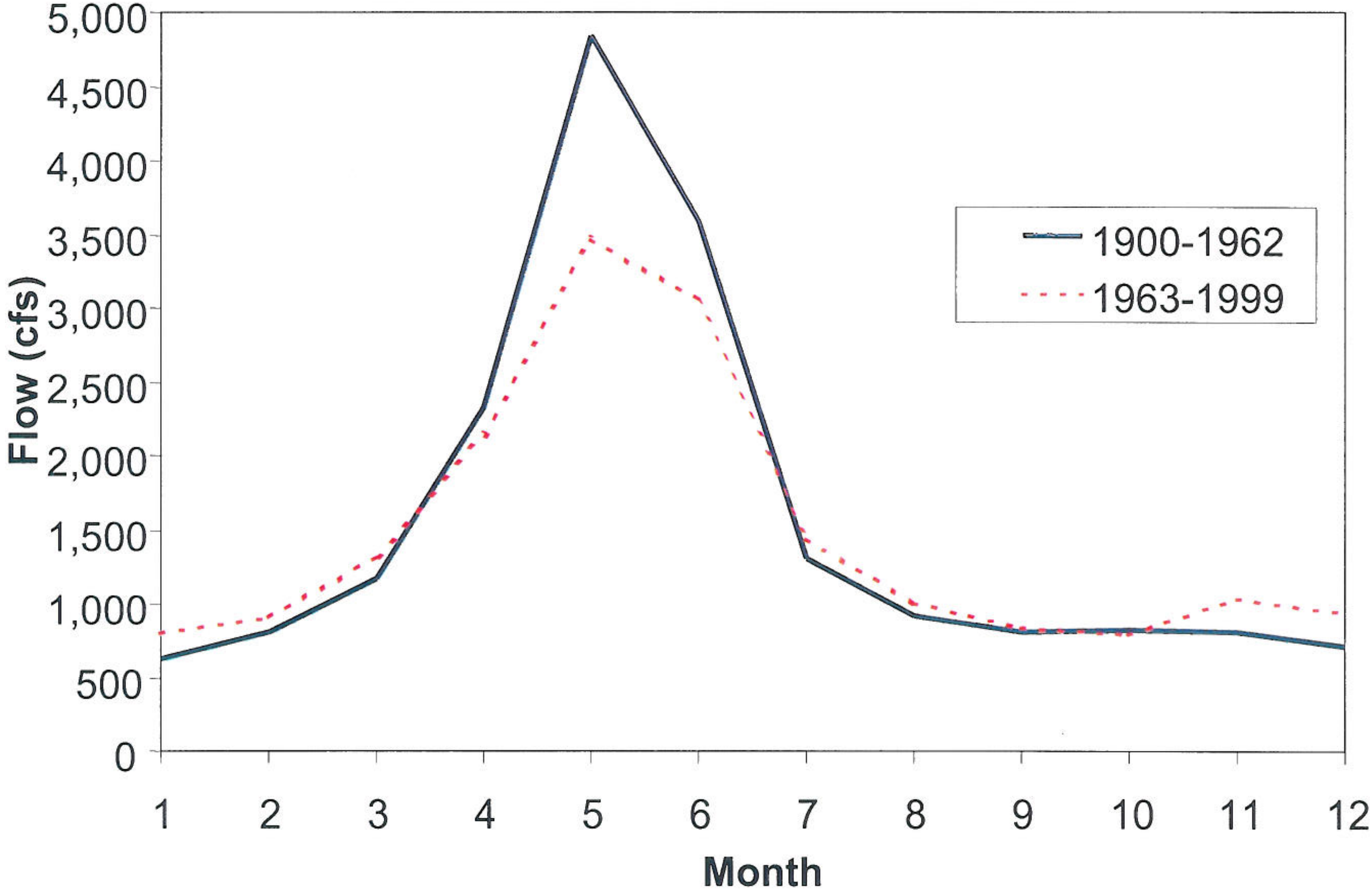
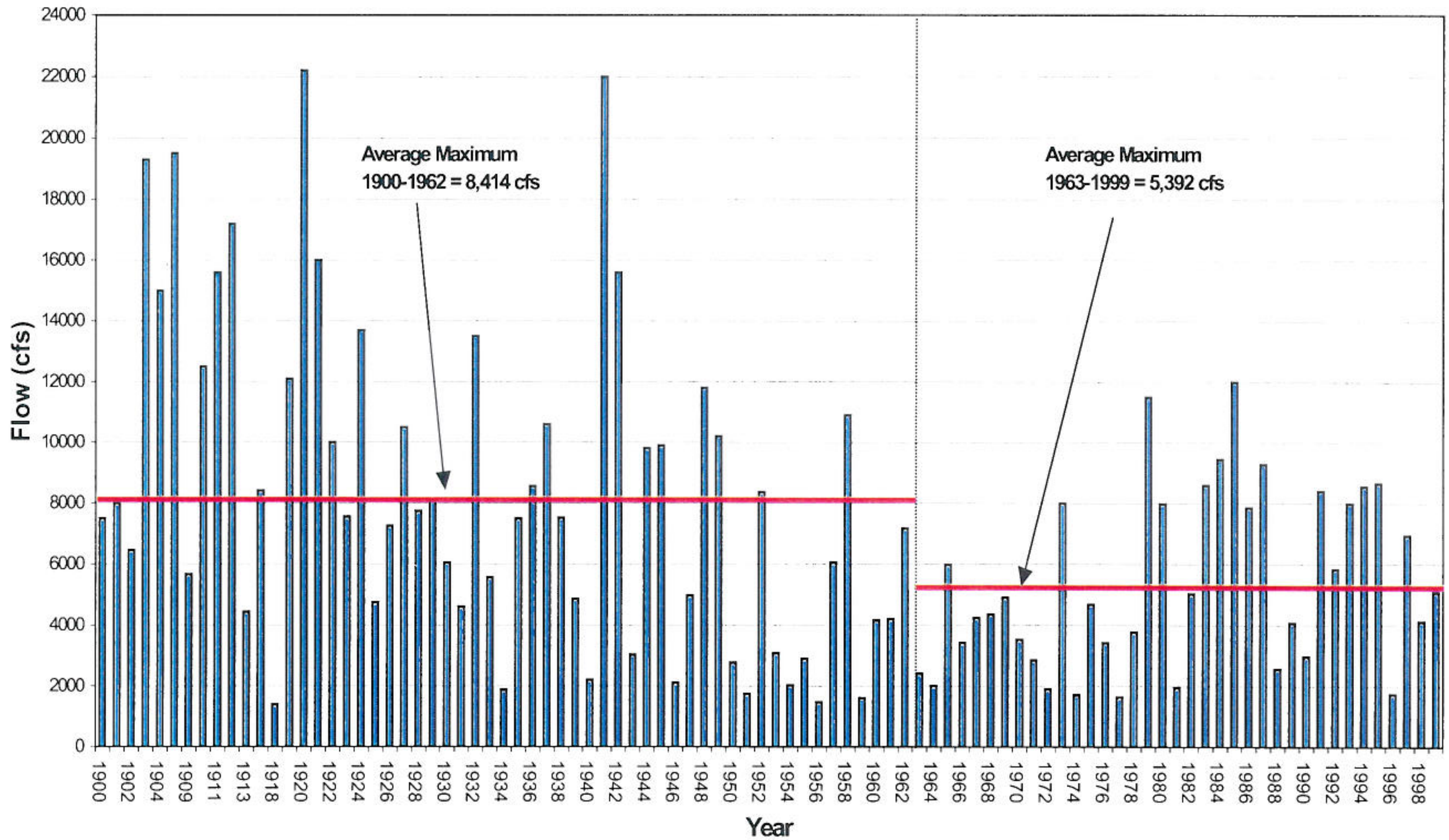


Figure A-12 Maximum Daily Flows by Year on Rio Grande at Otowi Gage, 1900-1999



Morphology of Rio Grande in the Buckman Area

Evaluation of Channel Morphology of Rio Grande near Buckman, NM

PREPARED FOR: CH2M HILL and Las Campanas de Santa Fe

PREPARED BY: Dr. Richard J. Heggen, P.E.

DATE: April 30, 2001

Introduction

At the request of CH2M HILL, an evaluation of the fluvial morphology of the Rio Grande near Buckman, NM was undertaken during the week of April 23-27, 2001. The primary purpose was to analyze the channel characteristics and morphology of the river with a particular focus on the suitability of a proposed water intake site on the east bank of the river several hundred feet south of the dead end intersection of Buckman Road with the river. The work consisted of a site visit on April 23rd by Richard Heggen in the company of Mike Sanderson, Las Campanas, Kathryn Yumas, Santa Fe County, and Walter Hines, CH2M HILL. Follow-up work included an evaluation of historic maps, ground photos, aerial photos, river channel data and streamflow records from a number of sources including Las Campanas, CH2M HILL, U.S.Geological Survey (USGS), the U. S. Forest Service, and the U. S. Army Corps of Engineers (Corps).

Morphological Evaluation

Present Conditions

Figure 1 is based on the USGS 1:24,000 White Rock Quadrangle published in 1984 and compiled from aerial photography taken in 1976. Location A is the proposed Las Campanas intake site. Location B is the terminus of the existing Buckman road which serves the riverfront and provides a portion of the right-of-way for the transmission pipeline for the City of Santa Fe's Buckman Well Field. The proposed intake site is several hundred feet downstream of the outlet from a small left bank (downstream perspective) arroyo, Location C. The site is roughly 1000 feet upstream of the Canada Ancha Arroyo outlet, Location D. The Canada Ancha is a major regional arroyo with a drainage area of several hundred square miles.

Initial field inspection suggested that the proposed river intake site should be geomorphologically suitable for a low-profile riverbank intake structure for several reasons. The site lies on the 'outside bend' of the Rio Grande channel where the channel is relatively narrow. The riverbed and banks are 'armored' with cobbles and boulders. The floodplain behind the site is well vegetated and, thus, apparently not often subject to severe erosion and 'back cutting' of the intake site.

Prudent design, however, requires more than assessment of current conditions. The Rio Grande is historically a mobile channel. Insight into the future comes from the historic record.

Historic Conditions

The proposed intake structure is situated several hundred feet upstream of the old Buckman Bridge crossing, Location E on Figure 1 and as indicated on Figure 2A. This bridge is believed to have been in place until the 1920s and possibly longer, before being swept away by floods. The early European settlers likely sited the bridge for the same reasons that the proposed intake is now sited: stable banks and narrow channel.

The Rio Grande is confined both approximately 0.5 mile upstream and one mile downstream by canyon walls comprised of basalt (See locations F and G, Figure 1). Between these constraints are ephemeral tributaries of the Rio Grande, the largest of which are the Canada Ancha from the left and the Sandia Canyon Arroyo from the right, both downstream of the intake site. The tributaries add coarse sediment in fanned outlets to the river. The Rio Grande has laterally meandered to obliterate and move downstream these fan deposits that would otherwise develop into sediment plugs.

The USGS 1952 White Rock Quadrange (based on 1947 aerial photography), as well as 1917 ground photos (Figure 2A) and 1935 aerial photos (not shown here), indicate that the left bank of the Rio Grande lay approximately along the Location H in the early 1900's. The 1952 quadrangle shows a 500-foot wide 'island' between that old left bank and the current alignment. In effect, prior to the 1950s, there were probably two channels in the vicinity of Location H. While the channel bifurcation looks like a 'meander cutoff,' the migration from Location H was likely more gradual.

The arroyos (Locations C and I) north of the intake are the most likely reasons for the bank shifting to the right (west) and filing in the west 'cutoff.' The arroyos drain several square miles at a steep gradient. Twelve-inch boulders in the arroyo, on the outlet fan and in the river bank at Location H and just downstream have been transported in recent years. Exploratory pits dug along the river bank have shown that these deposits are only several feet deep and overlay a more-uniform sand strata that extends to a depth of at least six feet (and probably considerably deeper). This observation will be explained shortly.

Debris from the left bank arroyos above the intake site intruded the river over the past century, evidenced by the sandy fan photographed in Figures 2a and 2b. The island shown in the 1952 quadrangle is that fan, then still occasionally cut behind by high water and/or tributary avulsion. (This report's 'island' designation stems from the 1952 mapping. True islands don't persist in sandy channels).

My conclusion is that the main stem of the river on that right (west) side of the old 'island' has been the main stem since the early 1900s. This is also the present alignment shown in Figure 1. This conclusion is further borne out by a sequence of aerial photographs obtained from the Corps of Engineers, Albuquerque District, show in Figures 3 through 7. These photographs, which cover the period 1976 to December 2000, show that the 'main stem' channel has been virtually unchanged over that period. Moreover, the aerials show the gradual invasion of vegetation on the former 'island'. The northern end, still swept by tributary flows remains more open. Note in the same figures the similar stabilization of another "island" at Location J. What formerly was a bar at the inside of bend regularly overtopped by floodwaters is now a stabilizing overbank feature.

Future Conditions and Intake Design/Maintenance Issues

A key issue related to the design of the proposed intake is the probability that the fluvial process will reverse and the main channel will return to the left (east) and possibly cut behind the structure. Three reasons suggest that such future change is unlikely.

(1) There is no augmenting sediment fan on the right bank pushing the river eastward.

(2) The reclaimed left 'island' upstream of the intake contains significant rock and is now well vegetated, making it resistant to persistent erosion.

(3) The most compelling reason for future stability is the decreased propensity for major Rio Grande flood events. Between 1900 and 1963 before Abiquiu Reservoir (a Corps of Engineers flood control facility) was completed on the Rio Chama upstream, there were nine years when peak daily flows at Otowi (four miles upstream of Buckman) were greater than 15,000 cubic feet per second (see Figure 8). Since 1963, peak river flows at Otowi have never been greater than 13,000 cubic feet per second.

The historic flood hydrograph also explains why the intake site isn't underlain with a deep cobble bed -- i.e., several thousand years worth of eastern tributary rock. Until Abiquiu was built, perhaps every 50 years a major event swept the channel, transporting away whatever debris had accumulated. The channel then again restarted geomorphologic pursuit of stability. Only since the reservoir completion has the Rio Grande been able to continue along that path uninterrupted by major floods.

Thus it is not likely that the Rio Grande will revert to the Location H alignment of a century ago.

The intake site is at the downstream end of the historic 'island' described previously. Before the channel's rightward migration, the intake site could have been (and probably occasionally was) backcut. The site now has the old 'island' as mature upstream protection. Additional upstream bank protection to further protect against 'backcutting' of the intake could be affected by constructing a slightly raised (and unobtrusive) access road to the intake (which is needed anyway) and using plantings or other ‘organic’ sideslope treatment to control erosion.

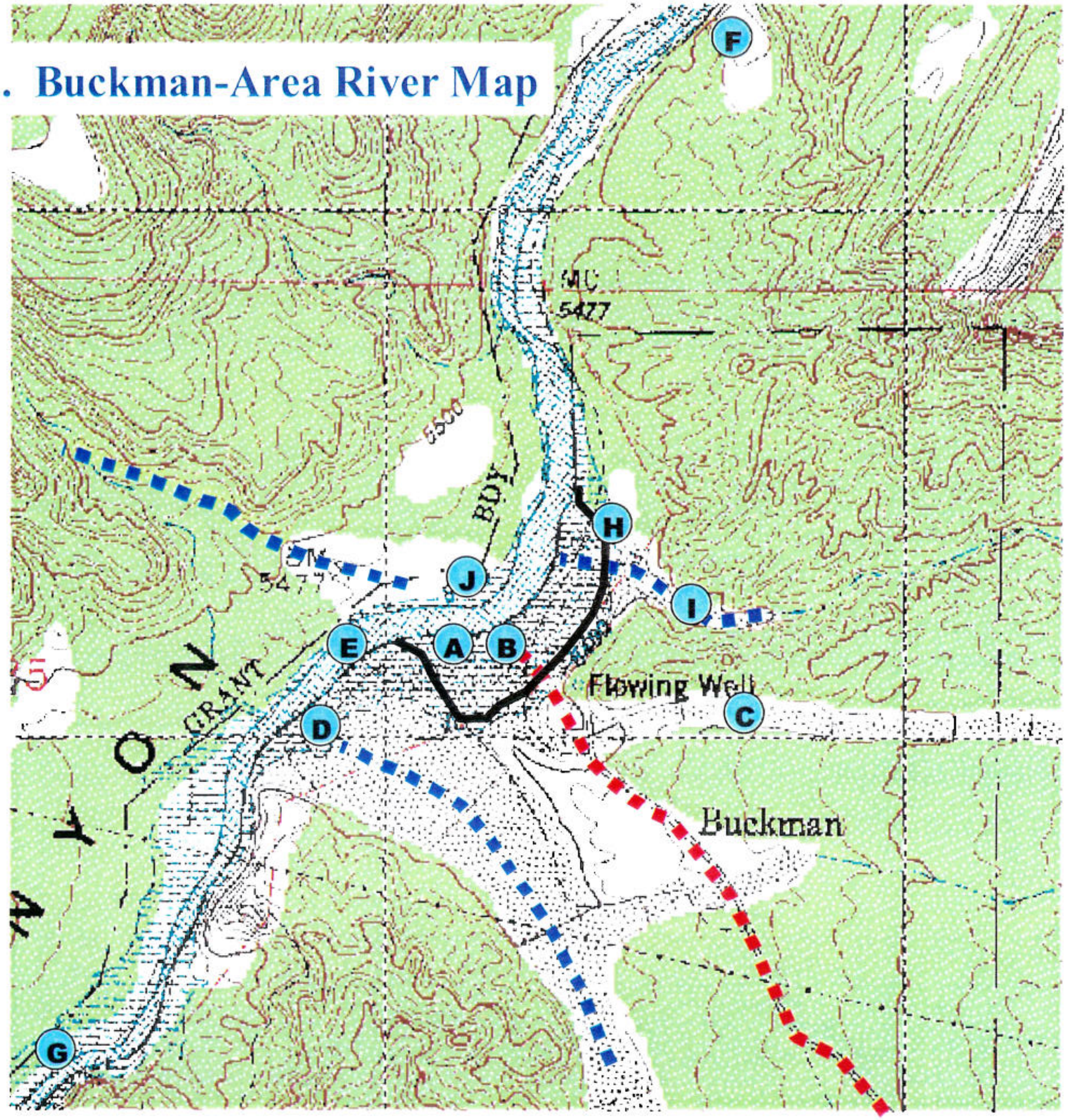
The Canada Ancha Arroyo has pushed enough boulders into the Rio Grande to stabilize the riverbed elevation below the intake. This will counter the possibility that the river will downcut at the intake site. Neither is the river likely to aggrade on the whole because, even with reservoir regulation, velocities are sufficiently high to transport fine sediment downstream.

Another geomorphologic issue relative to the intake design and location relates to the Canada Ancha Arroyo fan. This arroyo emerges from its narrow basaltic canyon east of the Rio Grande (evidence of the ephemeral channel’s long existence) and fans into river. At some past time, the Canada Ancha outlet swung (using the windshield wiper analogy) as far north as the proposed intake site. Currently the Canada Ancha outlet swings about a thousand feet south. However, it is possible (though not probable) that a large Santa Fe-area storm event could cause Canada Ancha outflow to cut north across the fan as far as the intake site. Arroyo debris could temporarily plug the structure.

While the river would eventually scour this intrusion away, the process could be hastened with a backhoe – i.e., the intake could be simply dug out. Given the potential for an uncontrolled Canada Ancha flood discharge, there is little alternative but to stand ready for rare-event intake maintenance.

The intake structure will protrude 10 or 15 feet into the channel, deflecting some Rio Grande flow toward the downstream right bank. That bank is replenished with tributary sediment and is historically mobile. Adjustment to the intake deflection will likely be indiscernible from the normal bank changes. The right bank should be monitored by aerial photography and can be organically treated if problems are noted.

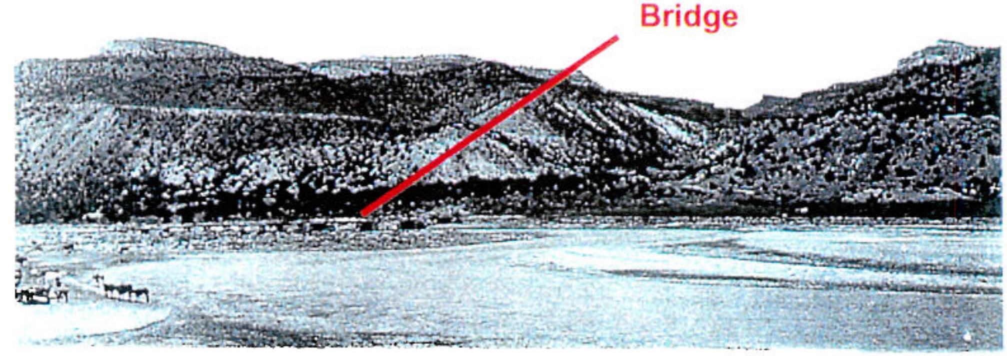
Figure 1. Buckman-Area River Map



A- Proposed Intake Site
B- Buckman Road
C, I - Eastside Arroyos
D- Canada Ancha Arroyo
E- Old Buckman Bridge
F - North River Canyon
G- South River Canyon
H, J - Historic River
'Islands' and Cutoffs

Figure 2. Views of Buckman Riverfront, 1917 and 1999

Source: USFS Archeologist, Santa Fe National Forest



A. Buckman Bridge across Rio Grande, 1917

B. Present-day view of Buckman Riverfront. Note change from 1917.

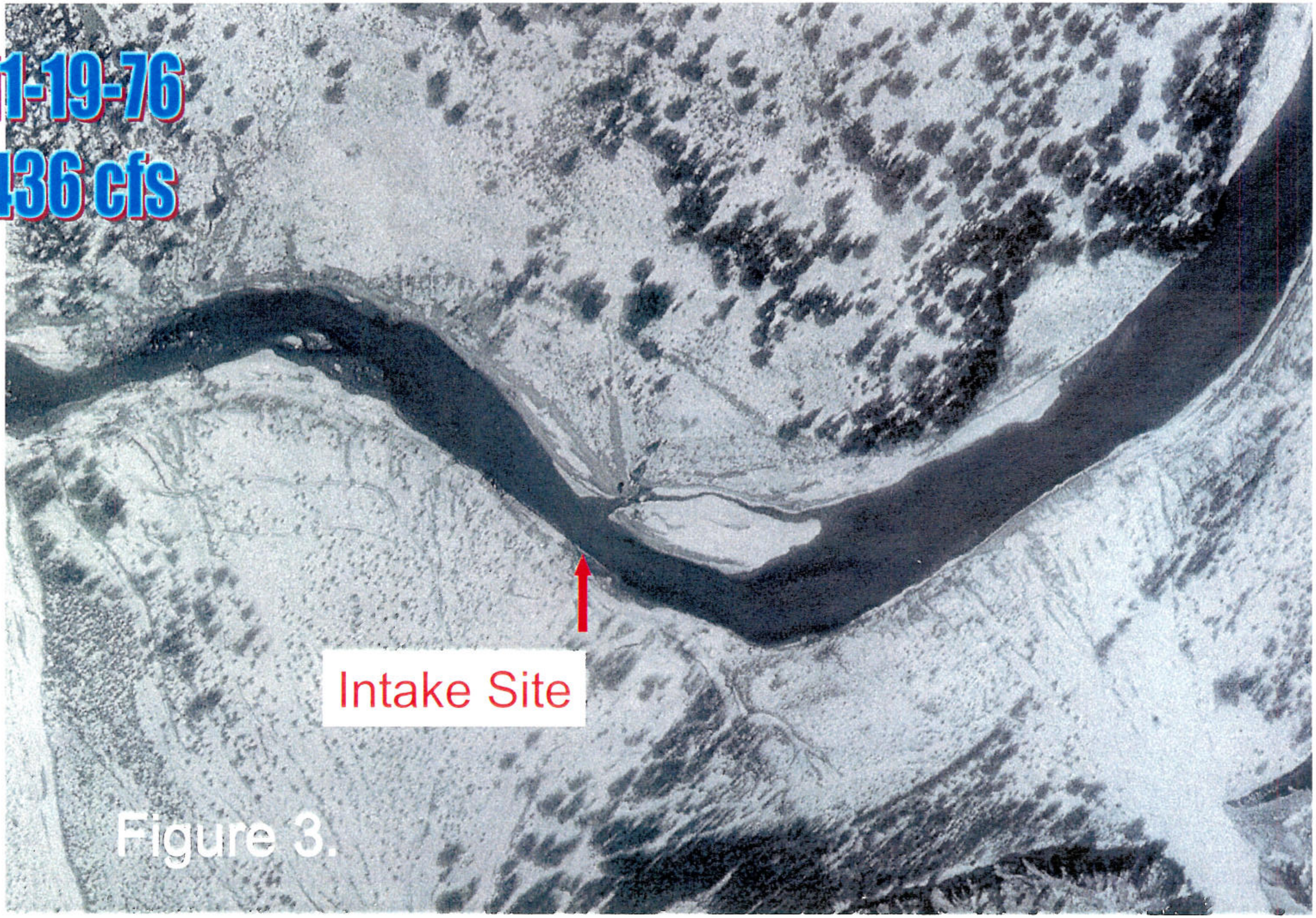


Figure 3.

Figure 4.


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Figure 5.

Figure 6.

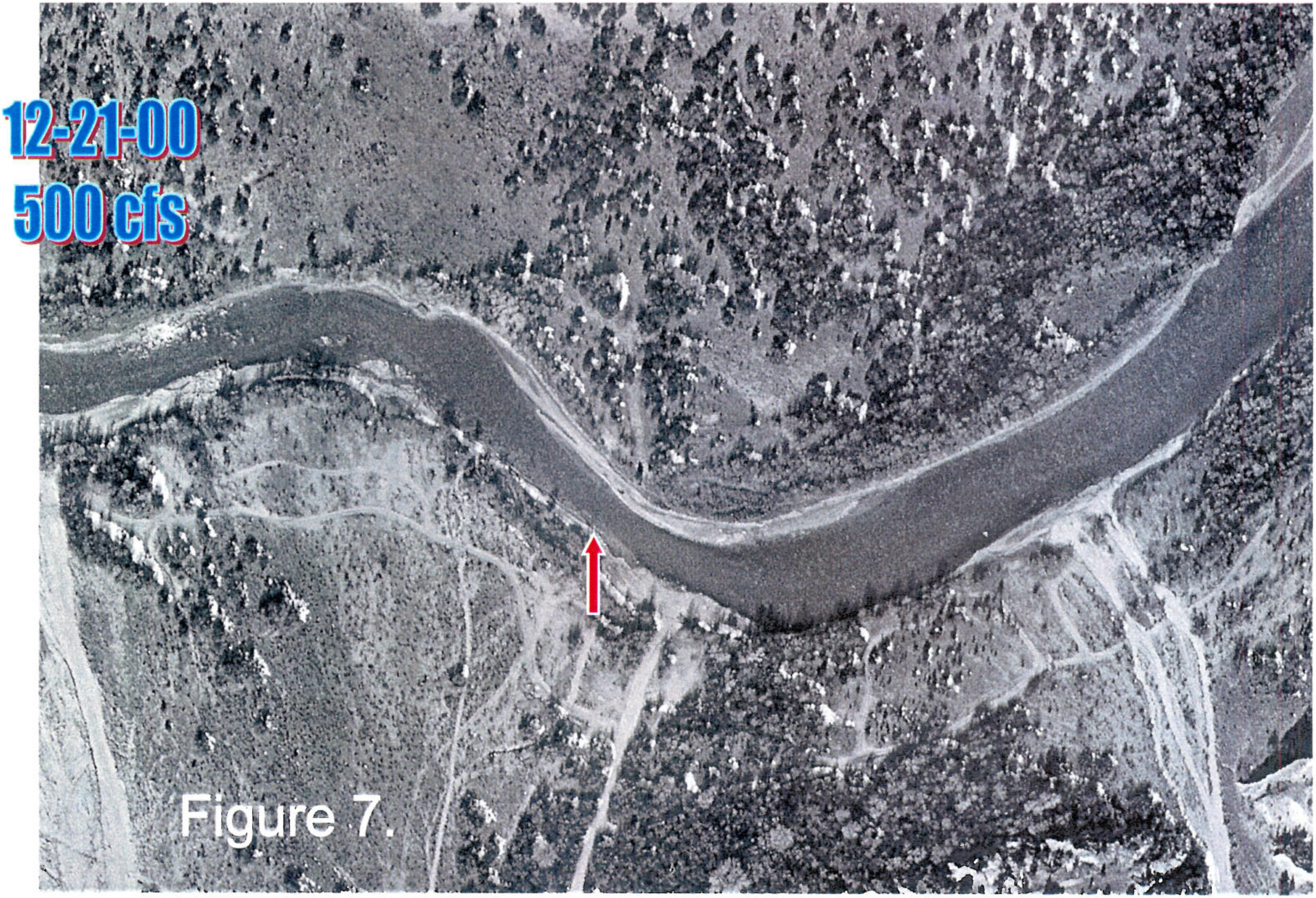
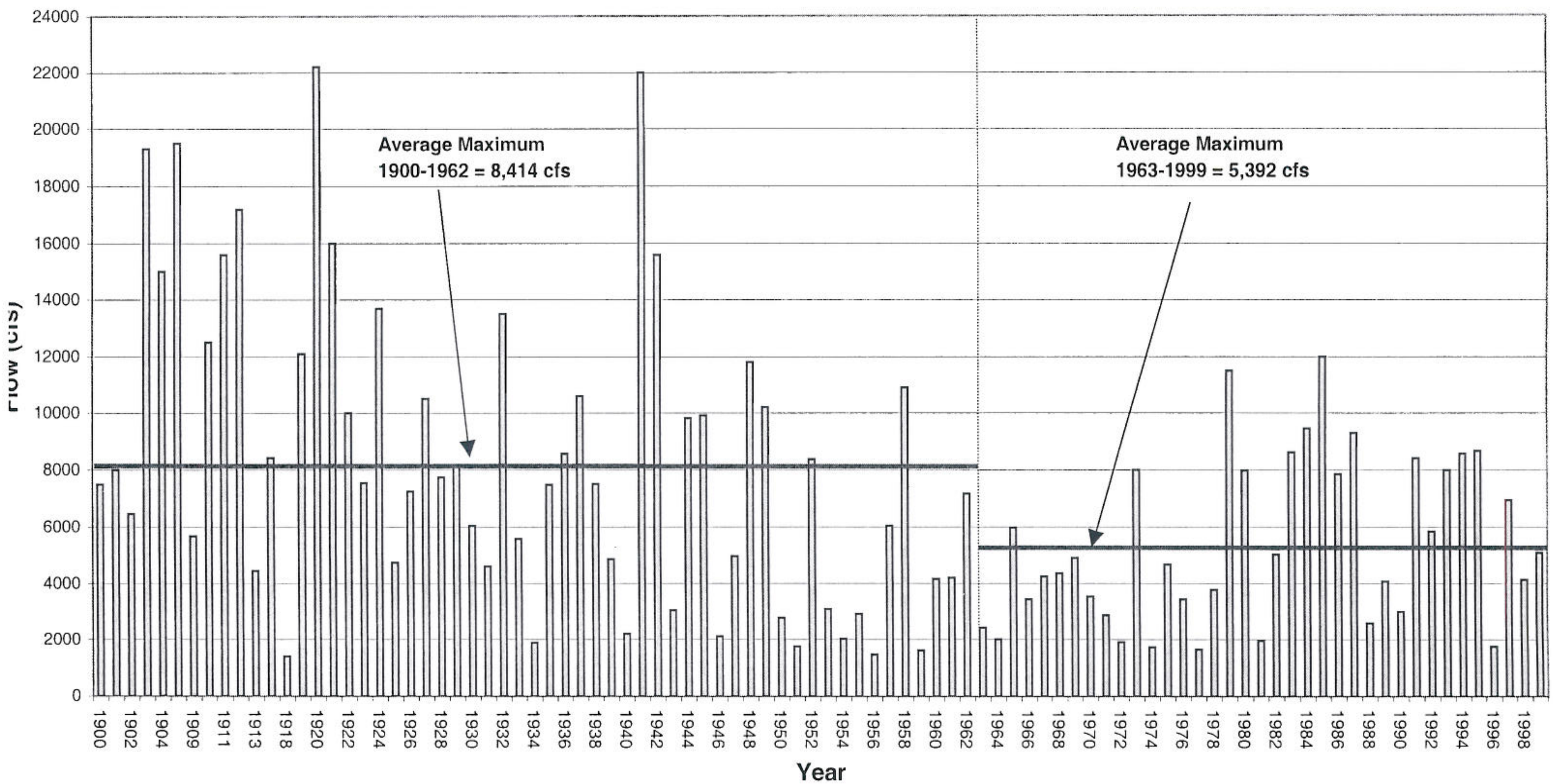


Figure 7.

Figure 8. Maximum Daily Flows by Year on Rio Grande at Otowi Gage, 1900-1999



Sedimentation of Rio Grande in the Buckman Area

Preliminary Las Campanas Intake Sediment Study

prepared for CH2M-Hill, Albuquerque
Dr. Richard J. Heggen, PE
September 20, 2001

Note: This document is based on a preliminary, pre-design evaluation and is subject to revision as design progresses. Several of the alternatives identified for sediment disposal from the proposed sedimentation basin are speculative and are presented herein for purposes of discussion only.

Study Objectives:

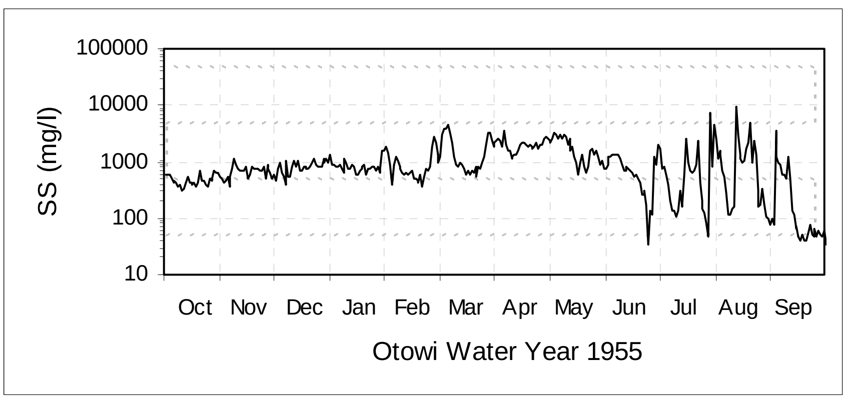
(1) To draw together and summarize the Rio Grande suspended sediment (SS) data pertinent to design of a water intake for Las Campanas at on the east bank of the Rio Grande at Buckman, NM. Particular concern is directed toward the months May-September, the season in which intake performance is more likely to be of critical concern.

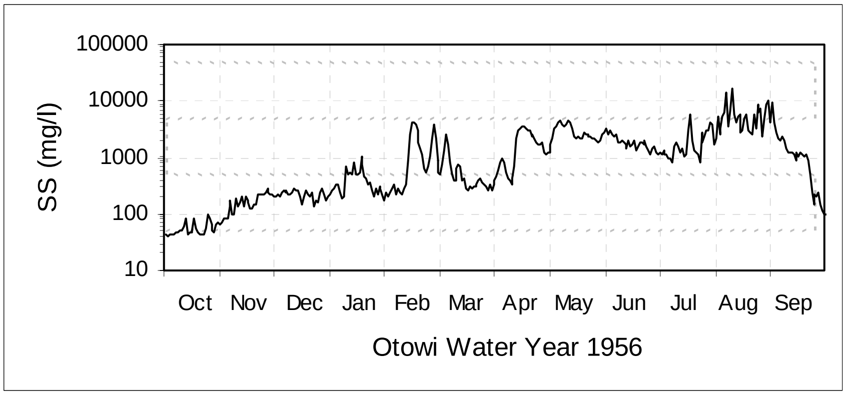
(2) To assess sediment issues related to the operation of the intake and the proposed sediment pond located some thousand feet east of the river bank on a terrace overlooking the Canada Ancha. The findings presented here should be reviewed in conjunction with final design.

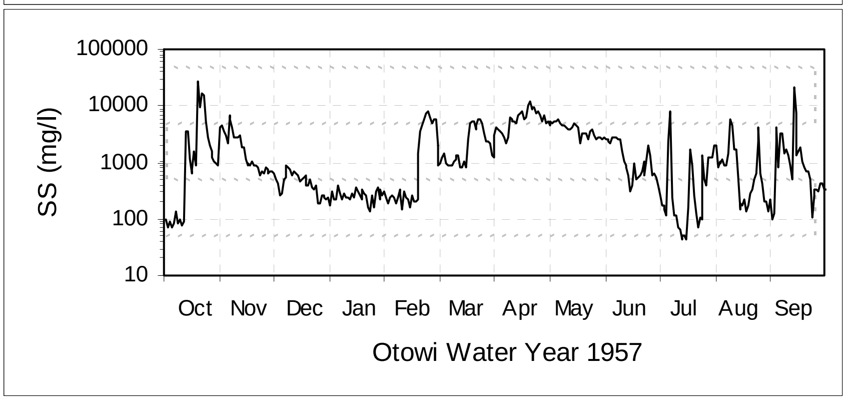
Part One: Data Summary

Rio Grande SS load at Buckman is described by historic USGS stream gage and water quality data available at the Otowi gaging site, four miles upstream of Buckman. No diversions and only minor ephemeral tributary confluences lie between Otowi and Buckman.

Daily SS concentration at Otowi has been recorded since 1955. The 45-year record illustrates the river's erratic nature. The plotted record follows. (A "water year" begins in October before the corresponding calendar year.) General observations are drawn after the plots.




SS (mg/l)
100000
10000
1000
100
10
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Otowi Water Year 1956


SS (mg/l)
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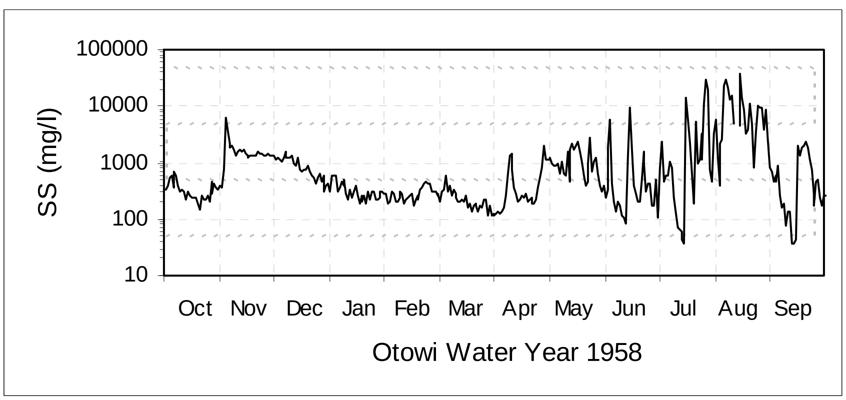
10000
1000
100
10
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Otowi Water Year 1957


SS (mg/l)
100000
10000
1000
100
10
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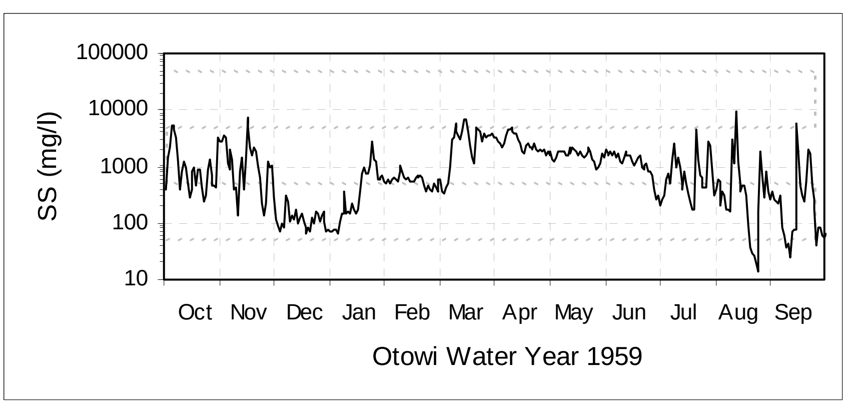
Otowi Water Year 1958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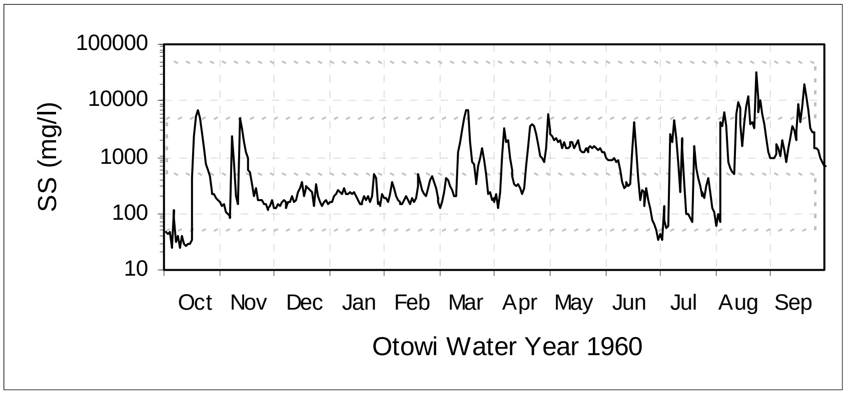
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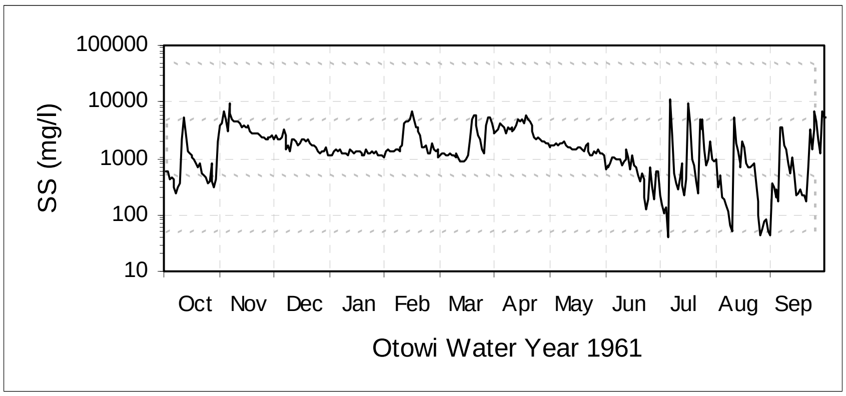
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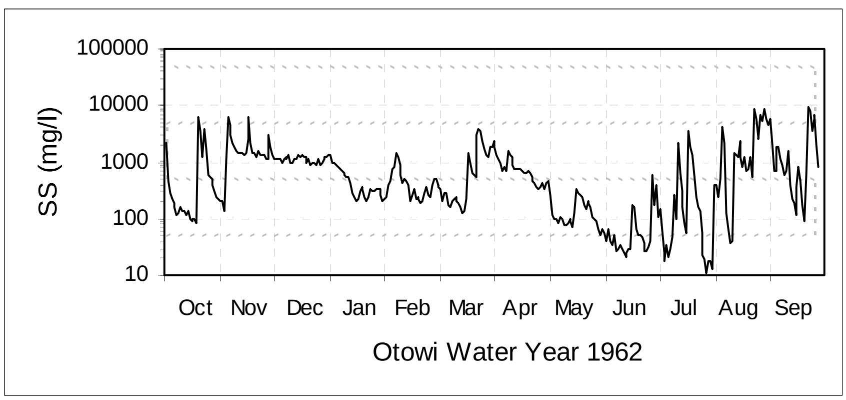
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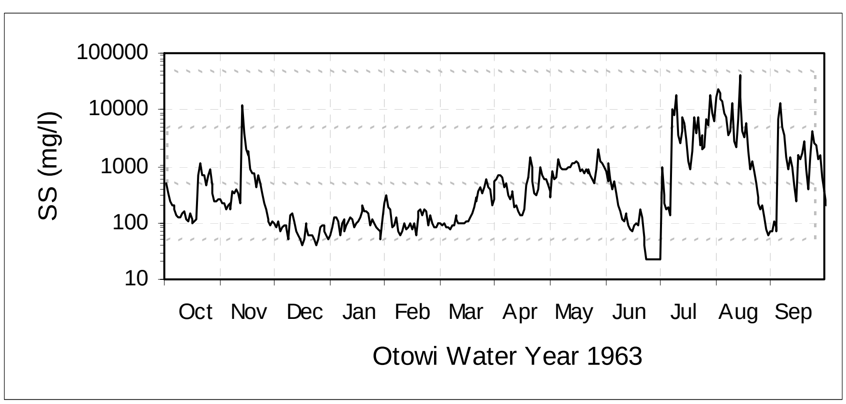
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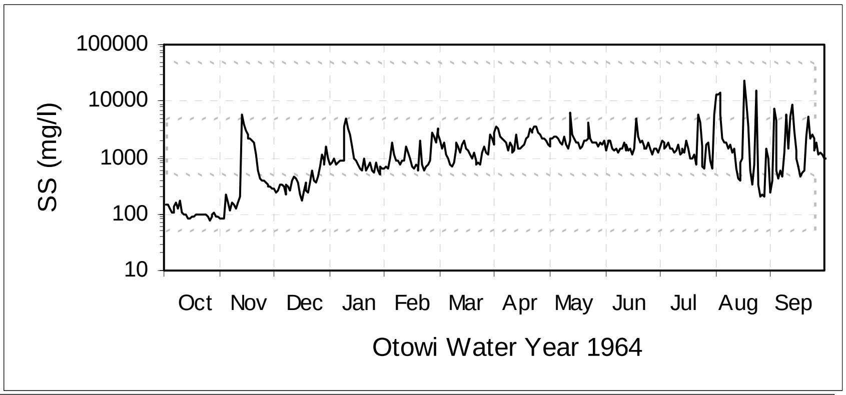
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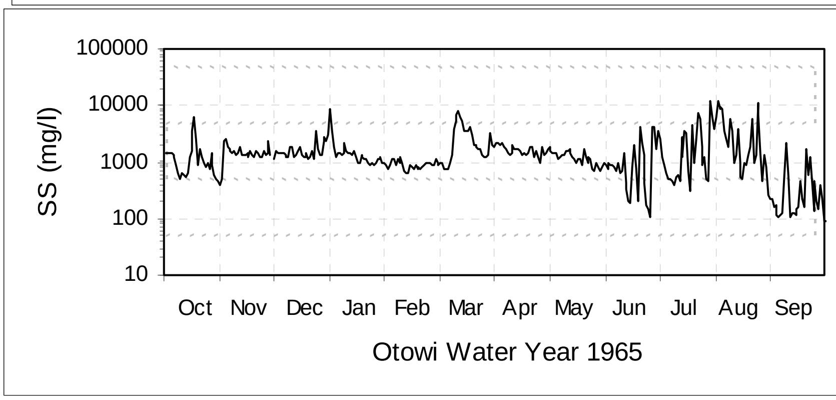
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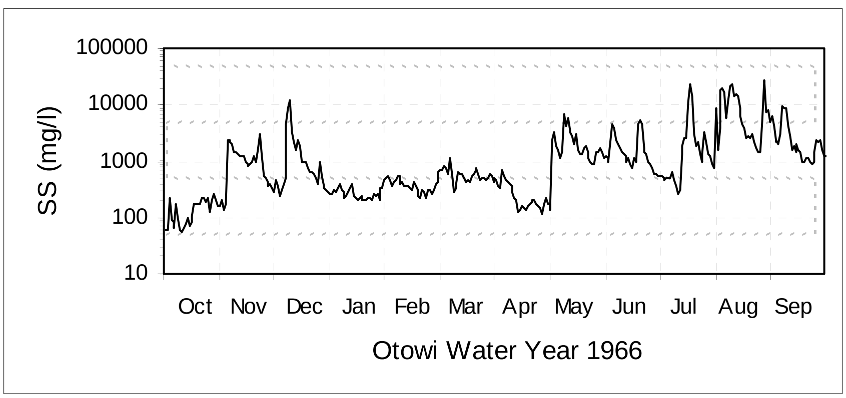
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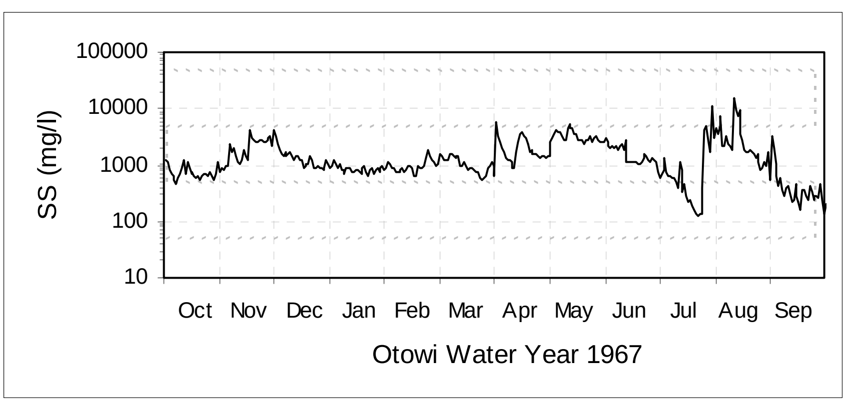
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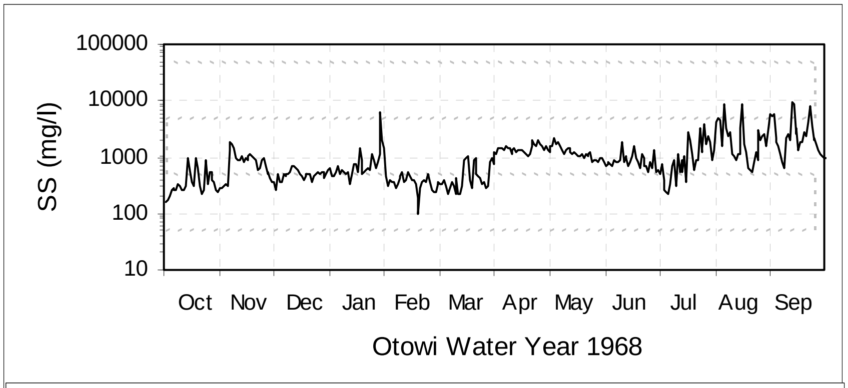
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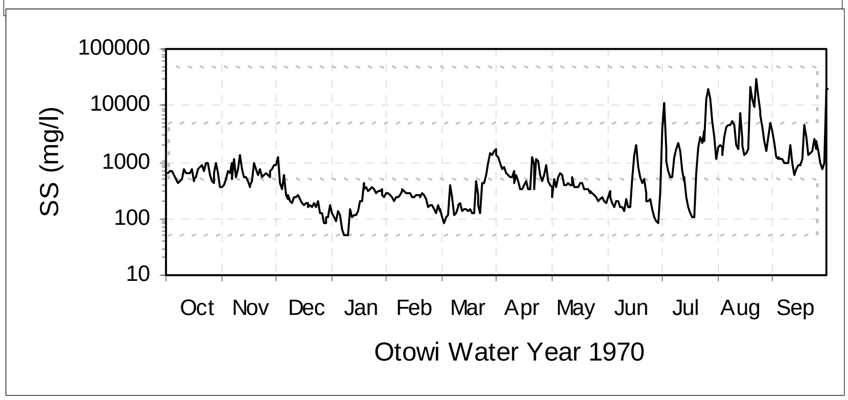
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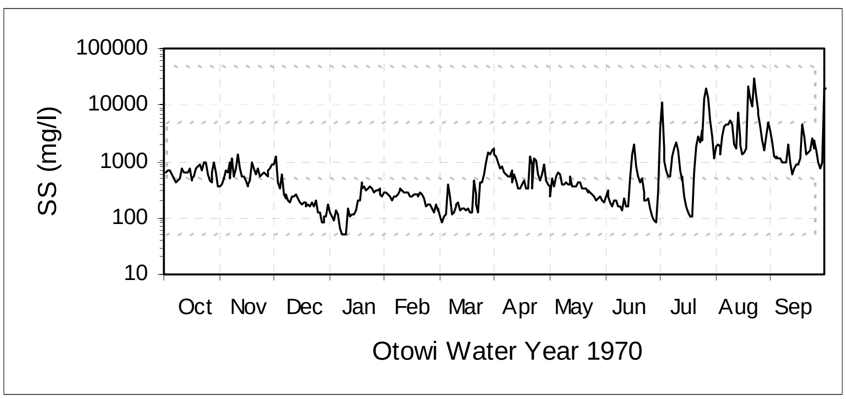
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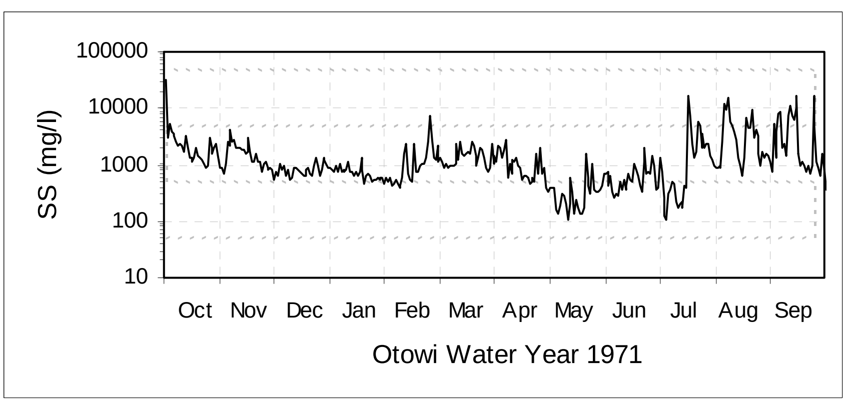
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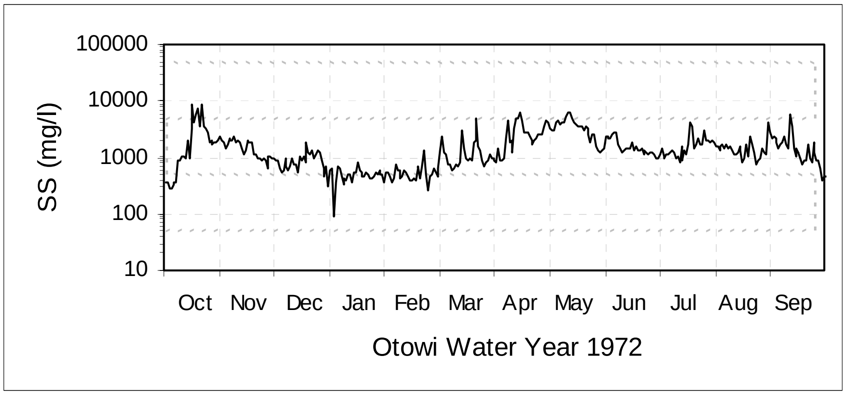
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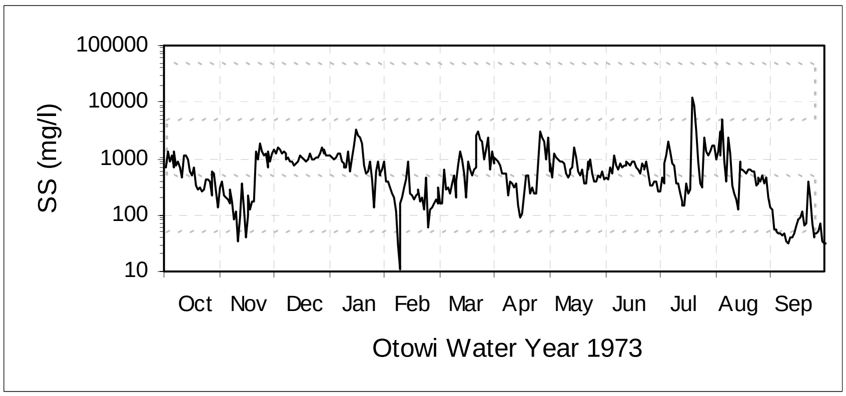
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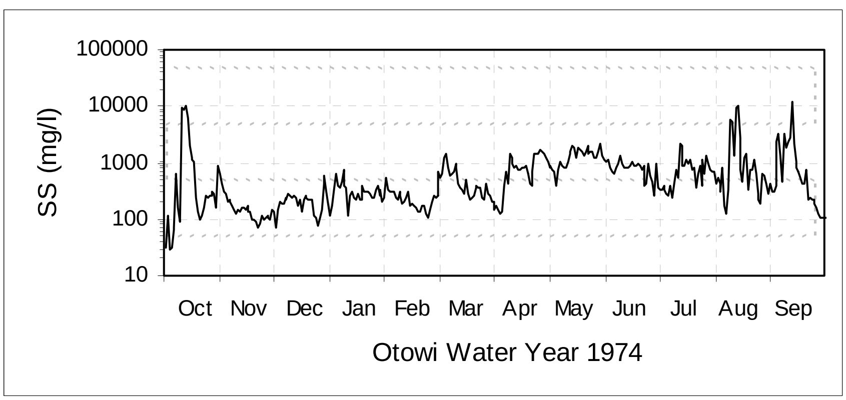
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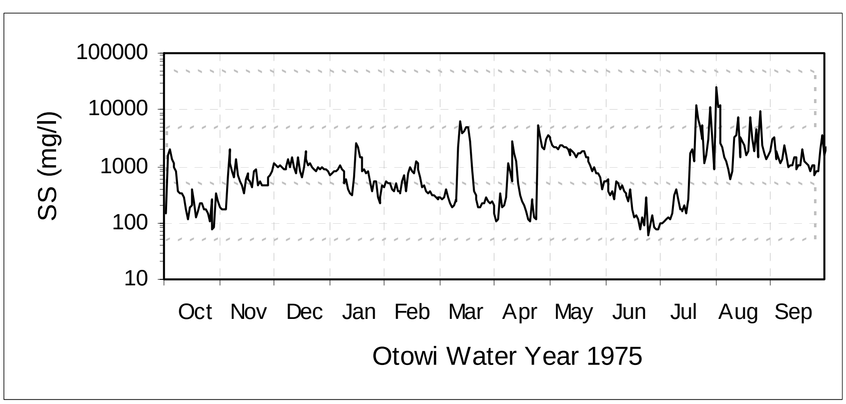
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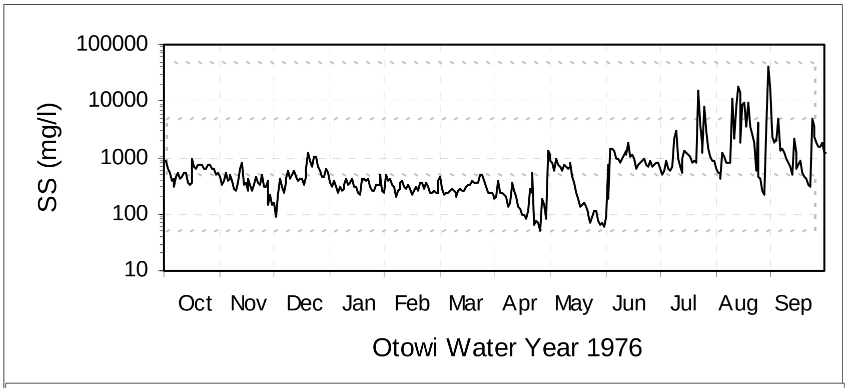
Otowi Water Year 1975



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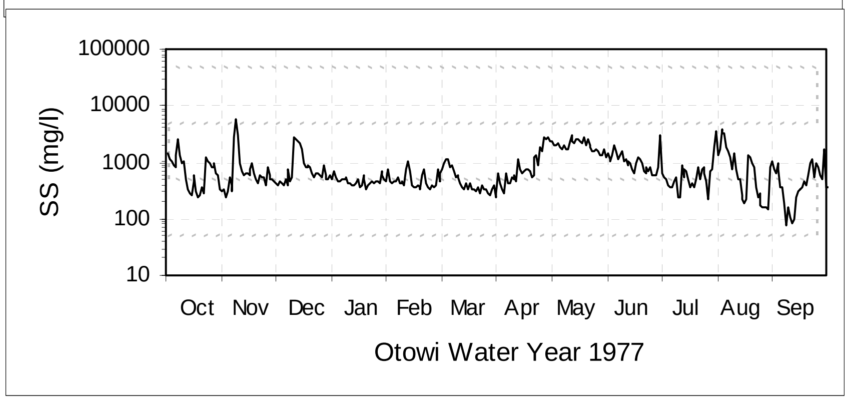
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Otowi Water Year 1976



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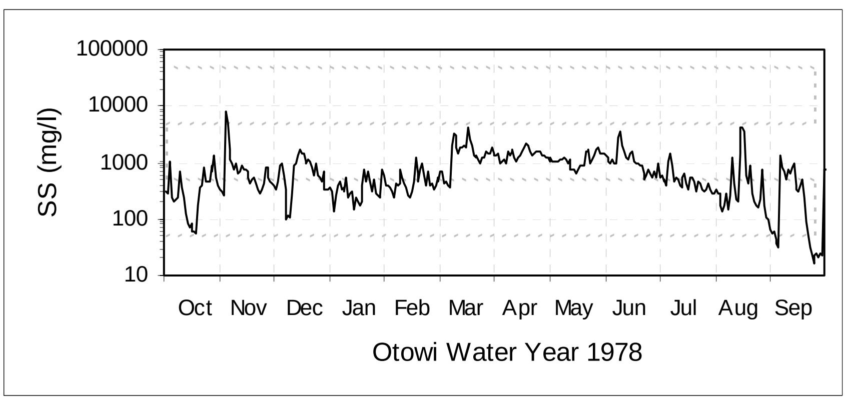

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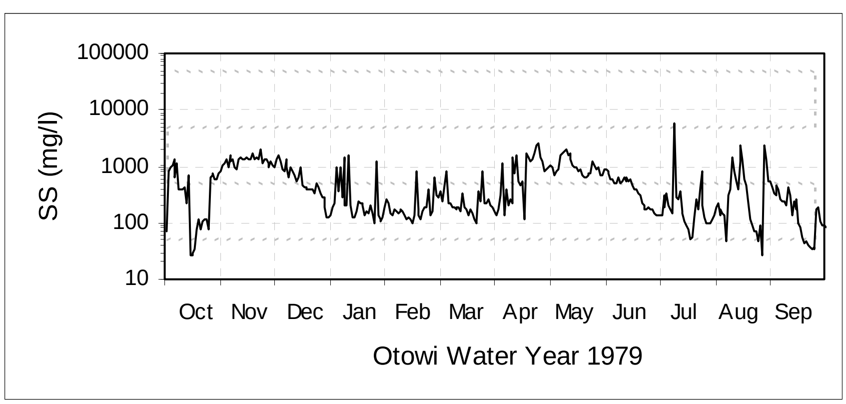

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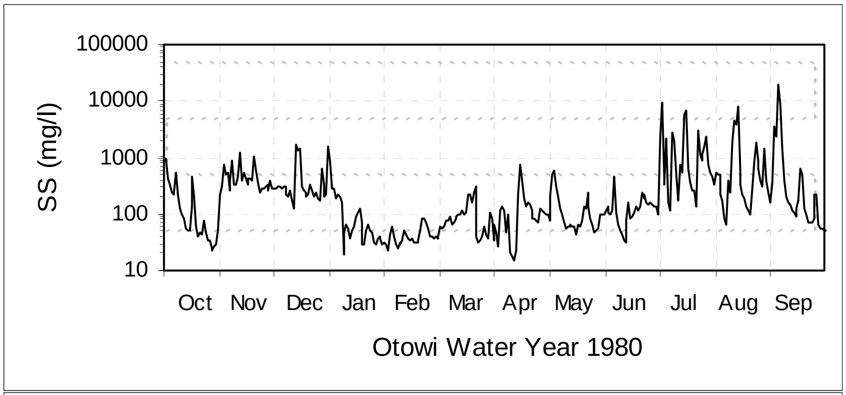
SS (mg/l)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Otowi Water Year 1979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SS (mg/l)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
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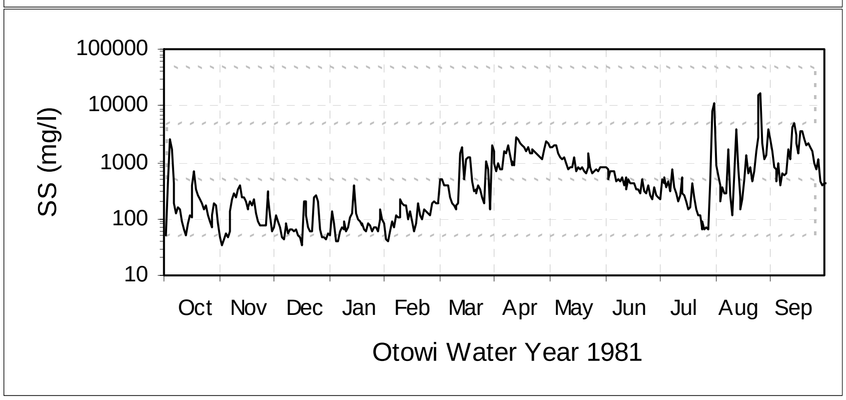
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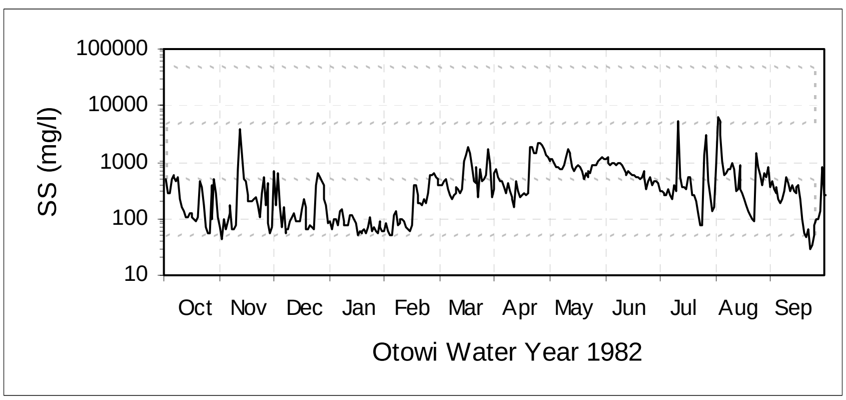
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SS (mg/l)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
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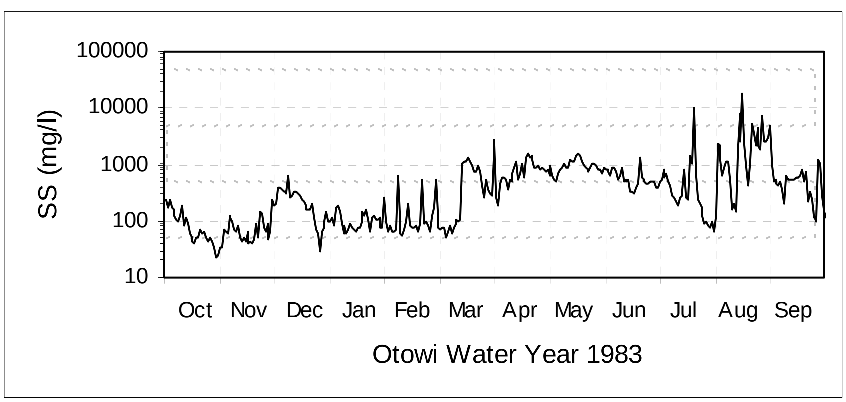
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SS (mg/l)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
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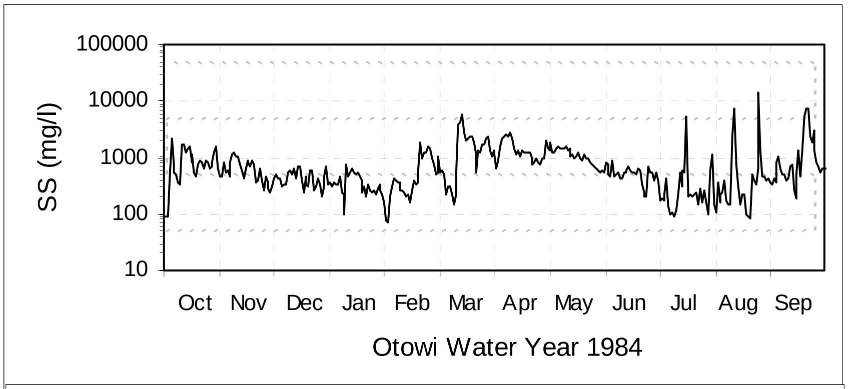
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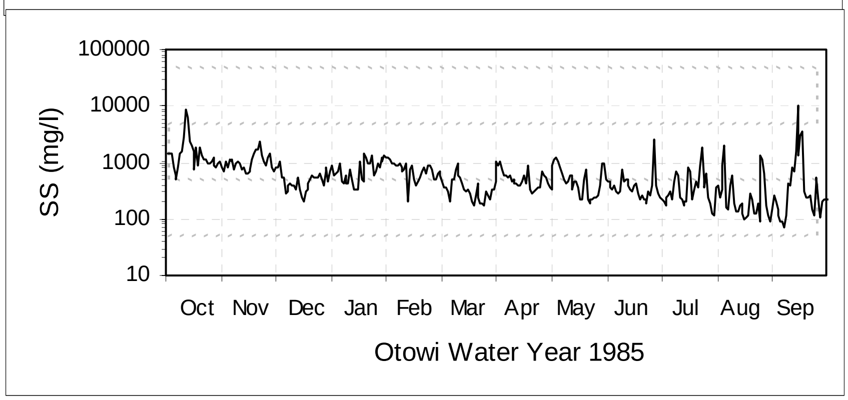
Otowi Water Year 1984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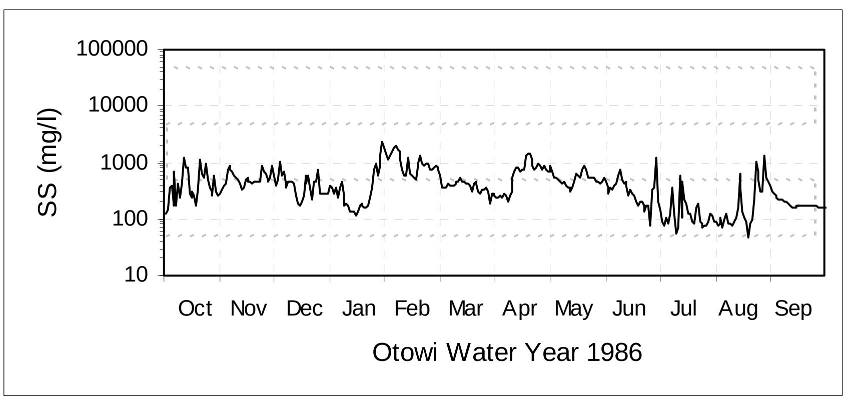
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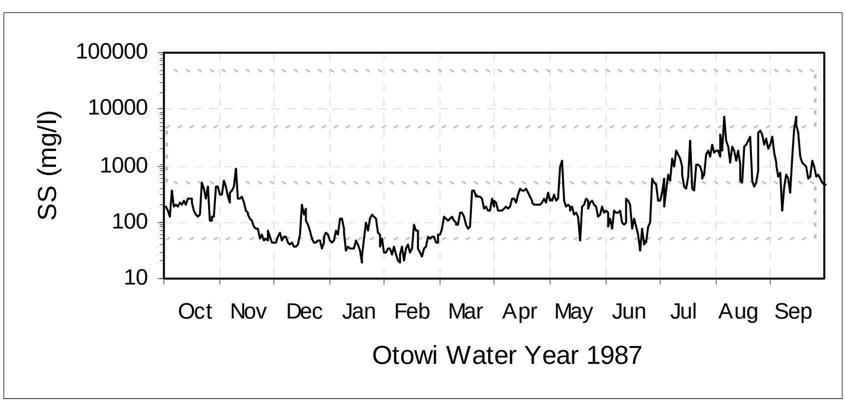
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SS (mg/l)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
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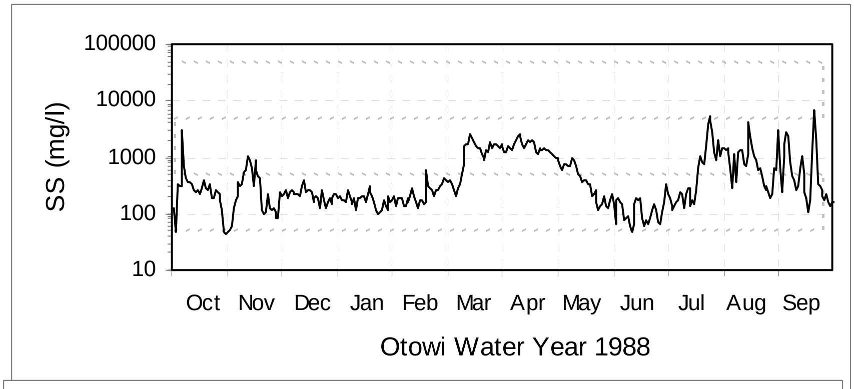
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SS (mg/l)
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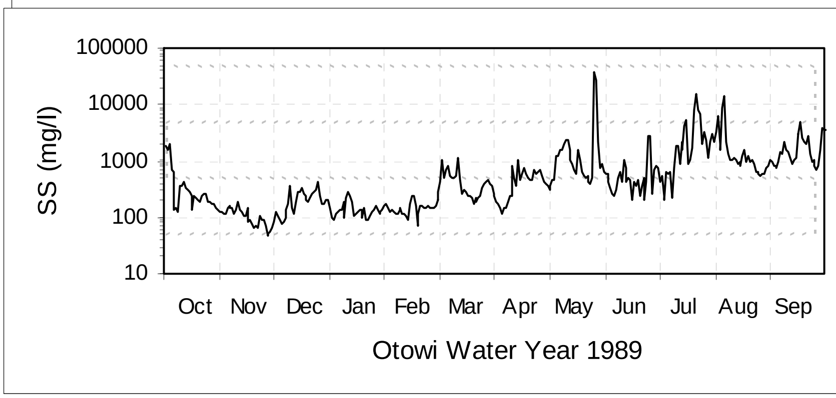
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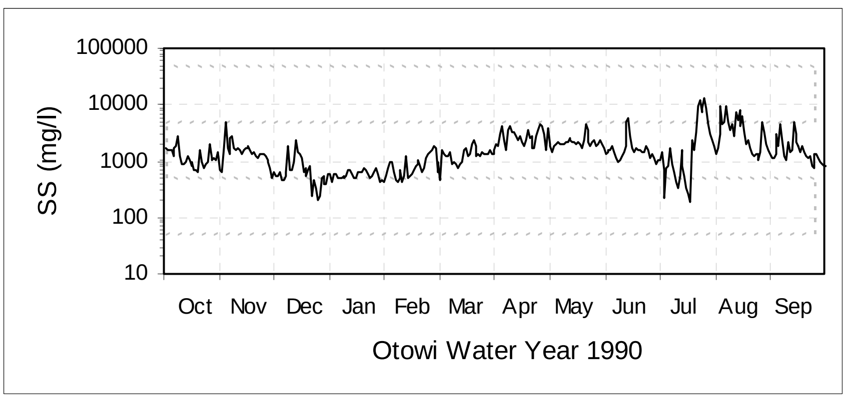
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SS (mg/l)
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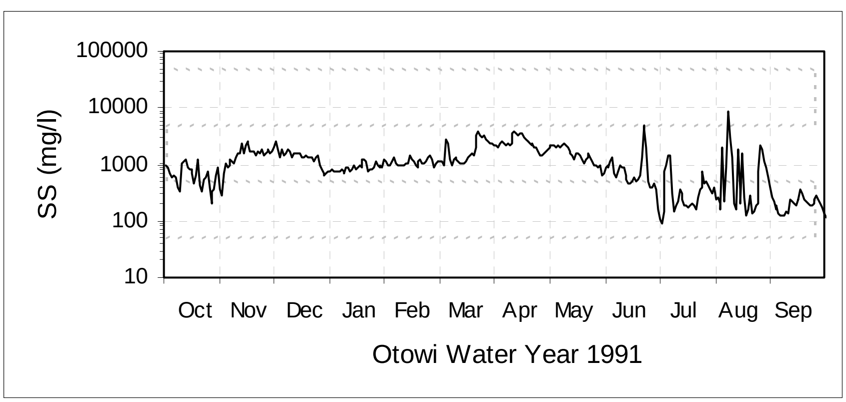
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SS (mg/l)
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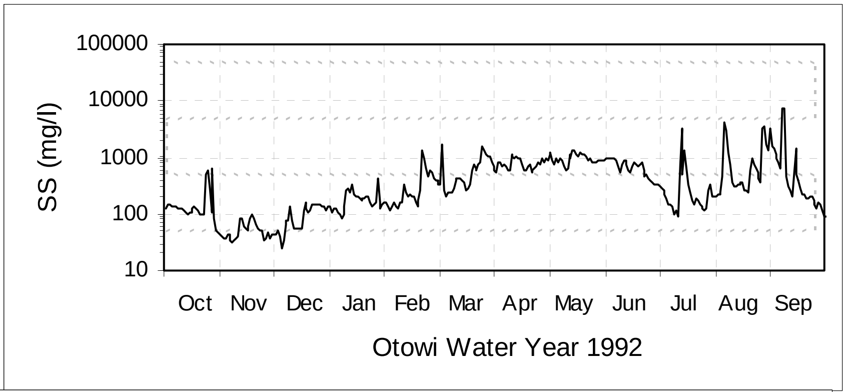
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SS (mg/l)
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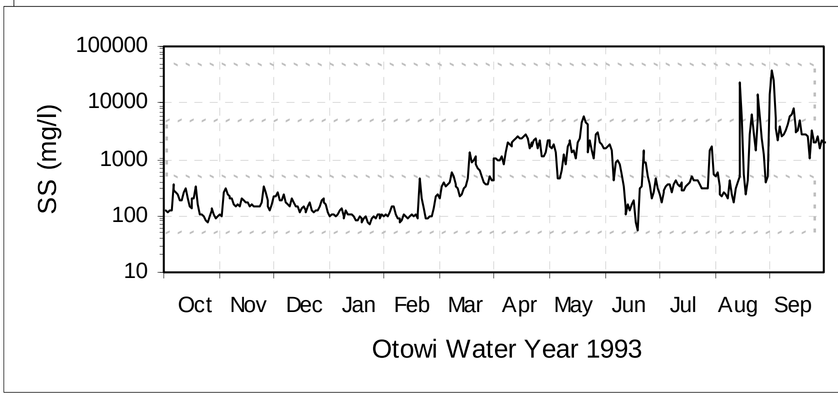
Otowi Water Year 1992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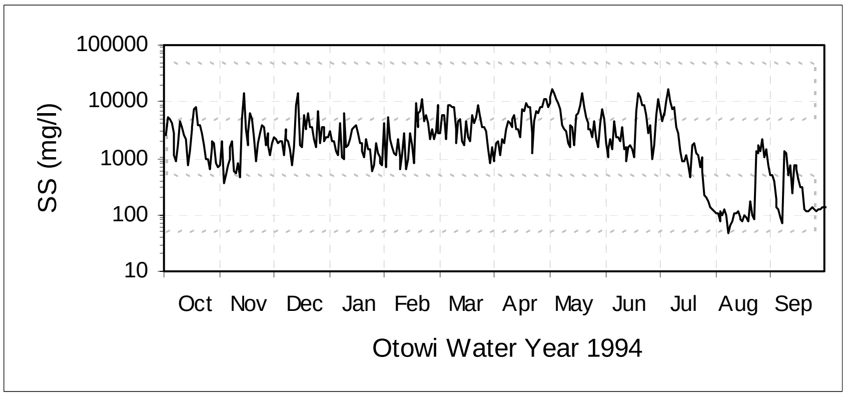
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SS (mg/l)
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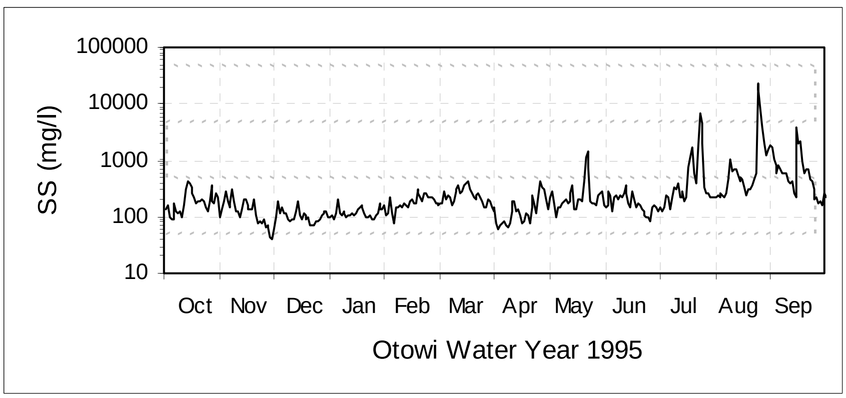
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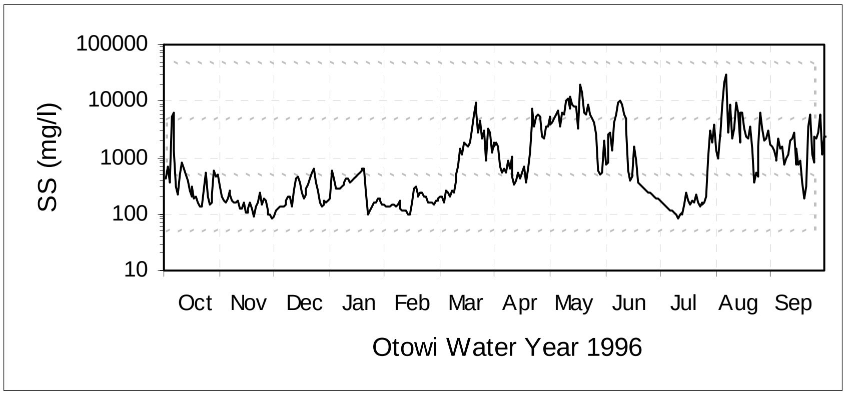

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SS (mg/l)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
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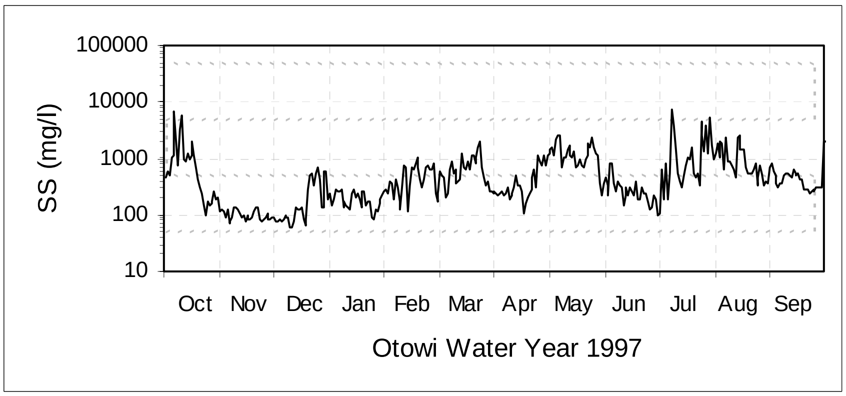

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SS (mg/l)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
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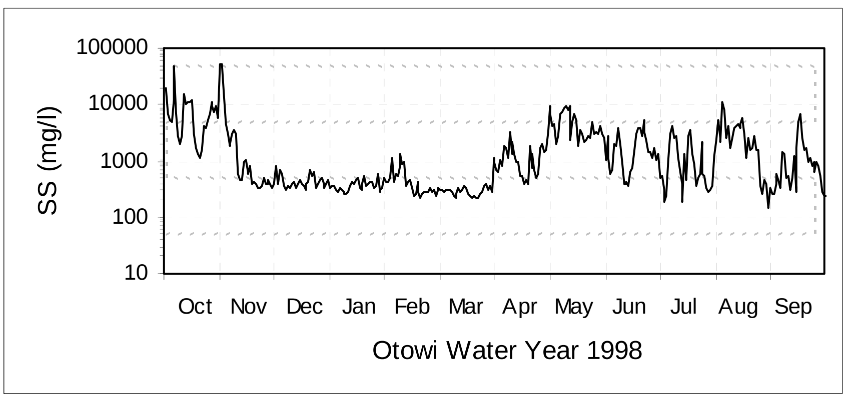

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SS (mg/l)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
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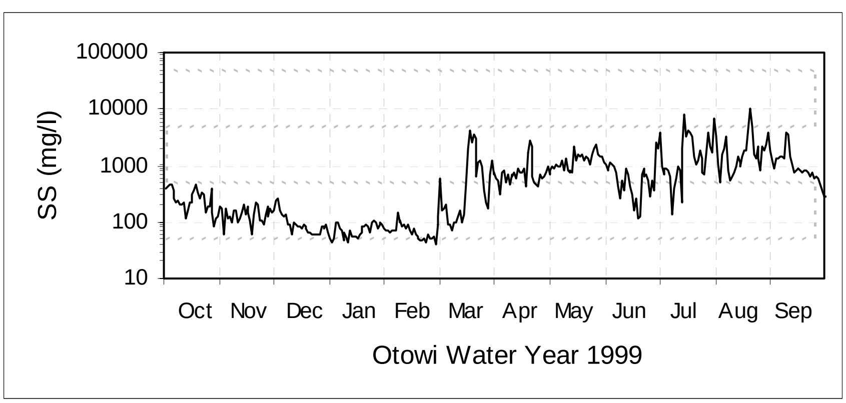

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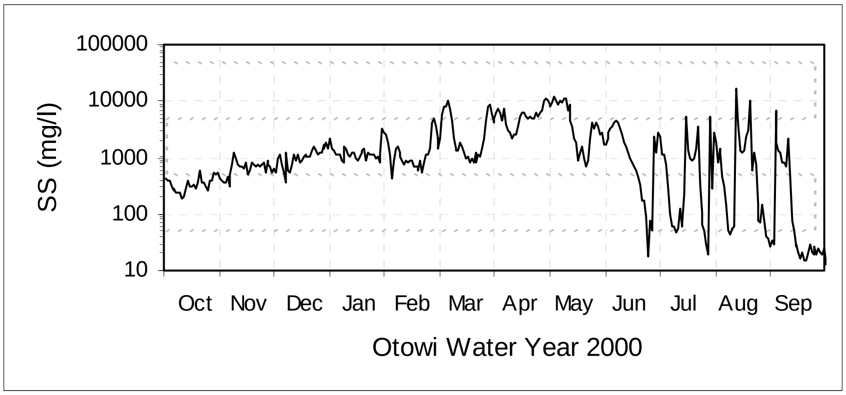
SS (mg/l)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Otowi Water Year 1999



The time-series plots suggest three generalities:

(1) The 45-year record shows no obvious overall trend. While one might anticipate trend relationships between SS concentration, upstream regulation (e.g., Abiquiu Reservoir began operation in 1964), water use and land condition, whatever occurs is indiscernible in the 'noise' of the record.

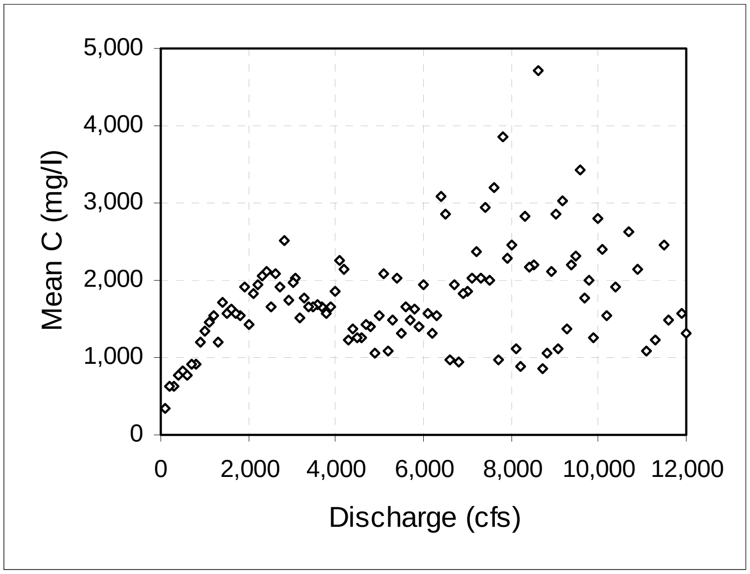
(2) No overall seasonal pattern of SS concentration predominates. The May-September SS concentration exceeds the October-April concentration in roughly half of the years and is roughly the same for most of the rest. Water Year 2000 is an exception. Following are mean monthly discharges.

Mean Monthly Discharge Q (cfs) at Otowi, 1885-1999

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
804	891	784	689	839	1,226	2,341	4,315	3,363	1,358	930	804

Q is substantially related to snowmelt. The more erratic, less sinusoidal SS record fails to mimic this seasonality. Were SS concentration to be regularly high in early summer, one might suspect that the snowmelt sweeps disproportionate overbank sediment into the channel. Were SS concentration depressed when Q is high, on the other hand, one might suspect SS to be bed-source limited. The poorly correlated Q and SS concentration record suggests neither general hypotheses. A supply-side model of SS seems unfruitful.

The following SS vs. Q plot represents 13,872 data pairs, 1955-1995. Plotting all the data yields a back cloud of points. This plot shows averages grouped by Q. Each point on the left side is the mean of 100-120 values. Each point on the right side is the mean of 20-30 values, as there were fewer large Q's.



Q and SS concentration are correlated up to Q of approximately 2000 cfs. The higher the discharge, the greater the turbulent diffusivity, and thus the higher the SS. Higher Q's show virtually no SS correspondence, suggesting, again theoretically anticipated, an upper limit on turbulence.

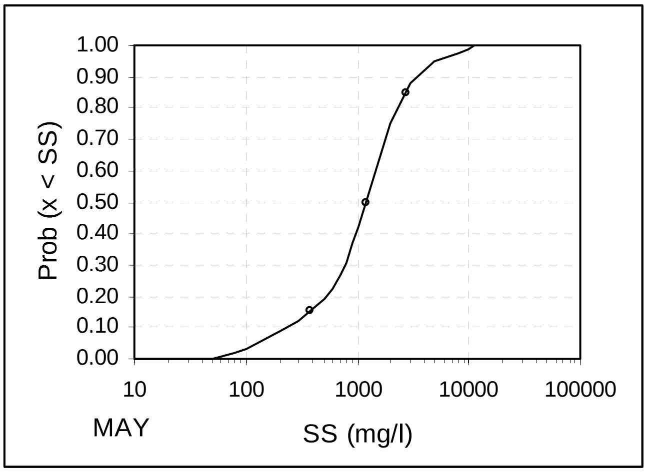
(3) The SS concentration record is erratic over the short term for most of the year, but particularly so in May-September. In many years, such variance is dramatically greater than seasonal change. This suggests that SS concentration responds to rapid change, albeit small in some cases, in Q. May-September is the season of short, convective rainfall. This is also the period in which upstream reservoirs release on a daily basis for specific demands. Pulsed Q picks up suspendable material from the bed, there in ample quantity. Subsequent streamflow is sufficient to keep much of the material in suspension. Presumably, such sort-term "overload" deposits in Cochiti Reservoir.

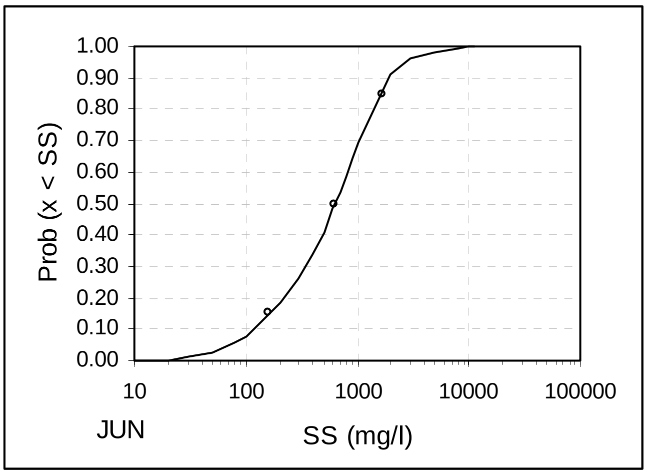
The three observations can be combined. May-September SS concentration is erratic, not well explained by steady-state transport mechanics. There is thus little reason to pursue one of the many river transport models (Yang, Meyer-Peter, Einstein, etc.). The intake should be designed for an SS concentration determined from the empirical record. The preceding figure suggests that this record is reasonably fit by,

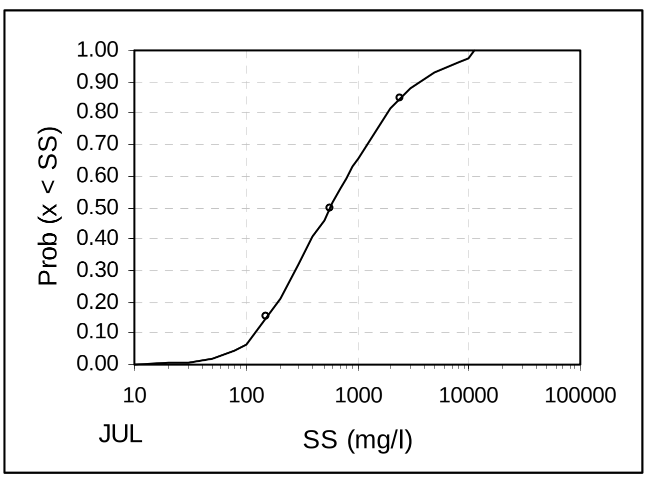
SS (mg/l) = 500 + 0.75 Q (cfs), Q < 2000

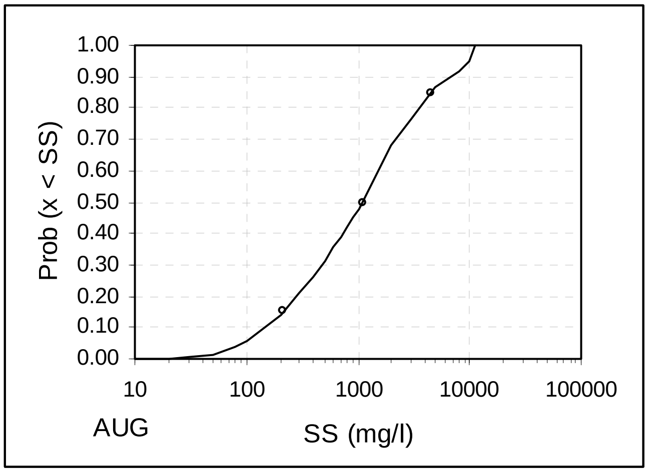
SS (mg/l) = 2000, Q (cfs) > 2000

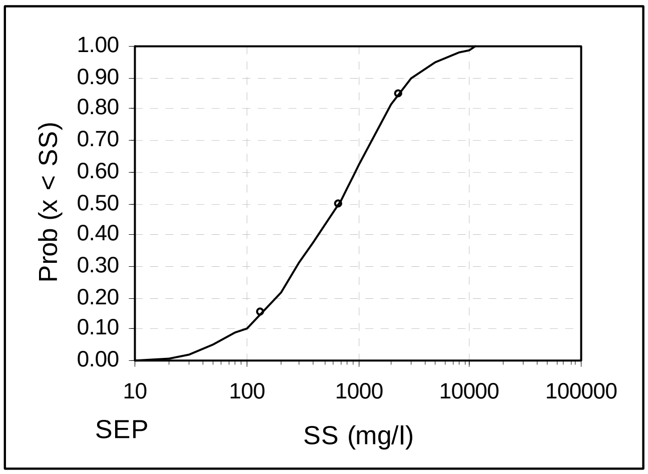
The short-term variability makes SS loading a stochastic problem. To that end, one can express SS concentration as probably of exceedance, as one would do with flood flows. The following five figures plot SS probably of non-exceedance by month over the 45 year record. The three points represent 15, 50 and 85 percent probabilities.


1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Prob (x < SS)
10
100
1000
10000
100000
MAY
SS (mg/l)


1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Prob (x < SS)
10
100
1000
10000
100000
JUN
SS (mg/l)


1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Prob (x < SS)
10
100
1000
10000
100000
JUL
SS (mg/l)





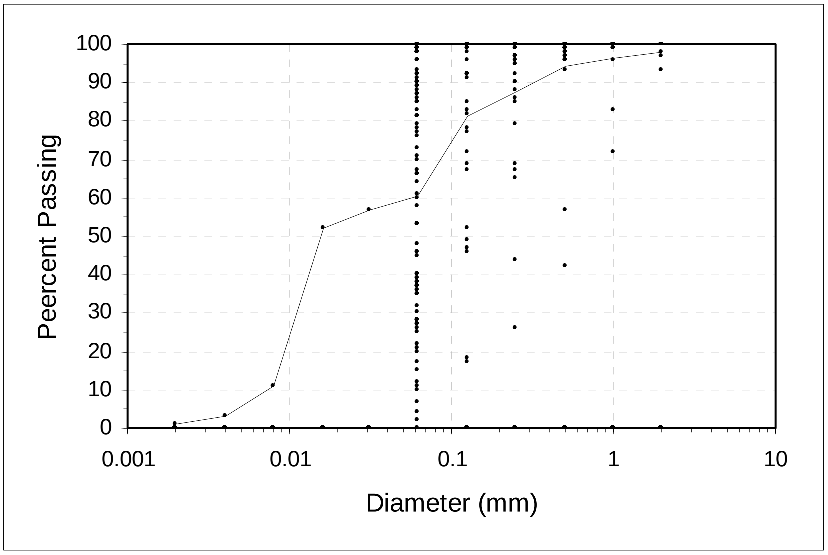
The table summarizes the distributions.

Suspended Solids (mg/l)					
Prob (x<SS)	Month				
	May	June	July	Aug	Sept
0.15	373	162	151	210	133
0.50	1185	628	568	1089	670
0.85	2759	1644	2456	4569	2339

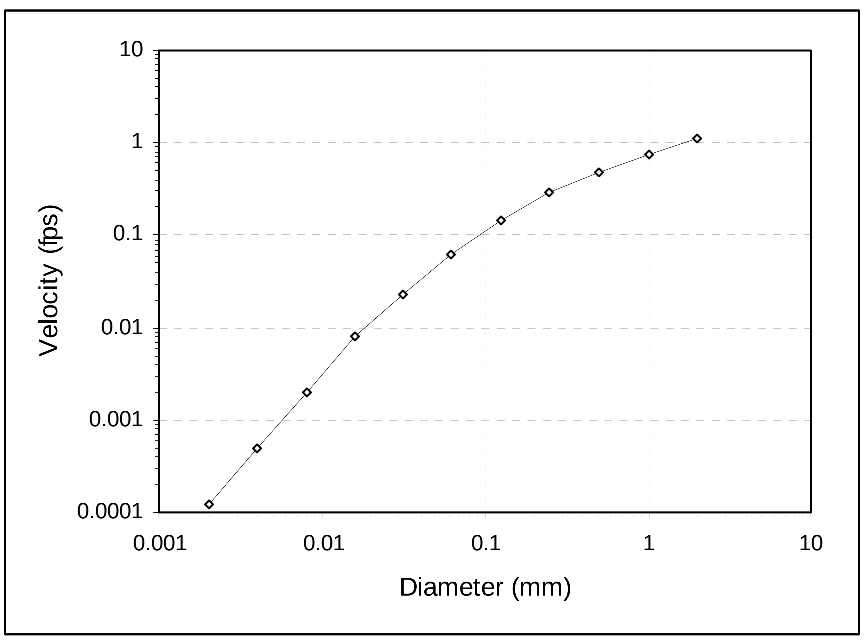
May and August, on the average, have the highest modes, roughly 1100 mg/l. One, however, would not size an intake for what occurs just half the time. If one, for example, wished to size the facility for a 15 percent exceedance probability, one might size for the 3000 mg/l range. An intake sized for this loading will be underutilized 85 percent of the time.

2000 mg/l is a reasonable conclusion from both the probability data and the earlier rough regression. Final design should be based on a prudent tradeoff between risk, economics and operation.

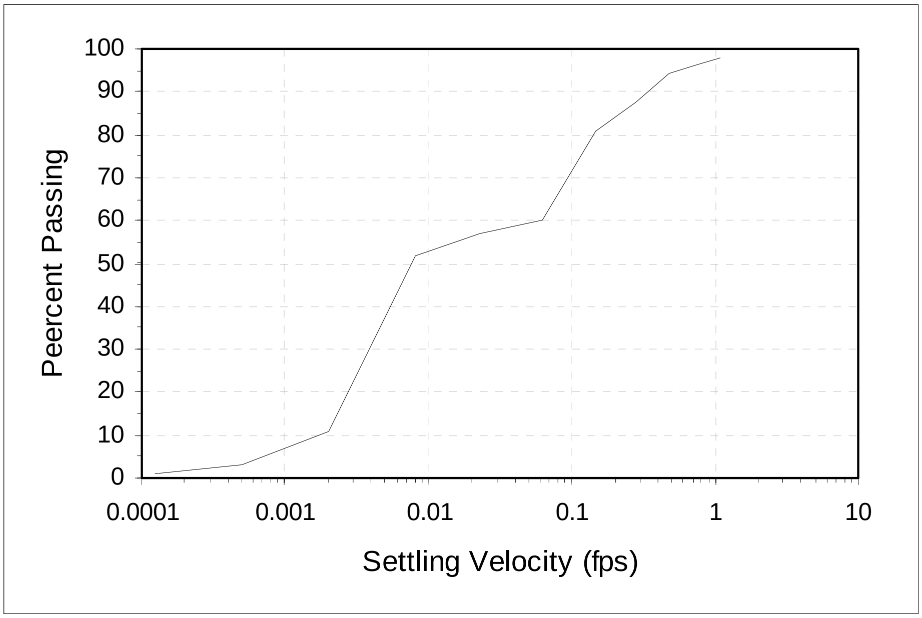
The following figure of SS size distribution is drawn from 87 gradation measurements in May-September. The plot shows the individual points and the means. The curve is relatively unreliable below 0.05 mm, as few measurements exist for this fine portion.



The next figure relates settling velocity to particle size. The leftmost three points are theoretical, as velocities are too slow for practical measurement. The remaining points are NRCS handbook values (NEH Sec. 3, Chapter 1, p. 2-10).



The subsequent figure transforms sizes to a corresponding setting velocity distribution.



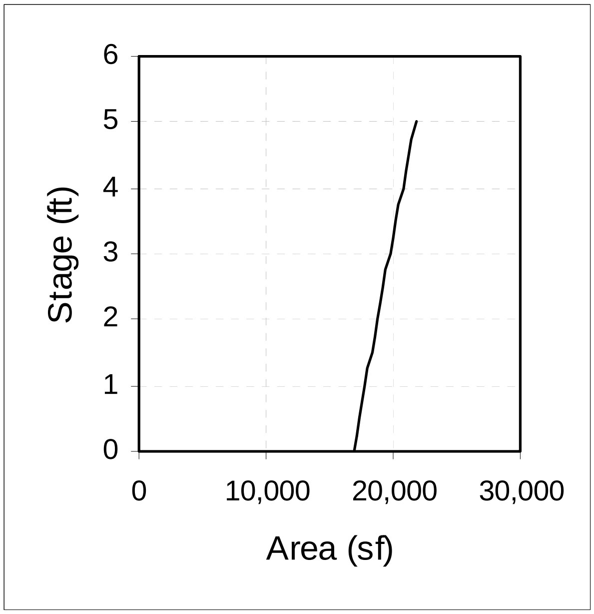
Part Two: Intake Design

The intake consists of the following components:

(1) A multi-screened intake in the river. The proposed 1.75-mm opening is reasonable based on the particles. Bedload will not pass 1.75-mm slots and local (abutment-type) scour should preclude bedload piling in front of the screen. A 1-mm opening only slightly reduces the material passing the screen and would create higher entrance head loss. Manufacturer 's specs are needed to pursue this topic.

This study presumes no SS removal at the screen. Occasional material exceeding 1.75 mm may lodge in the grating, but most of what doesn't enter through the screen will be then swept onward in the main channel. 1-mm particles may settle behind the screen in the compartments just upstream of the pipe leading to the proposed low-head submersible pumps. Sloping and sculpting the intake bottom can help sweep such deposition onward into the conduit (item 2). As the screen will collect occasional floating debris, it must be monitored, sparged with compressed air, and/or raked clean as needed.

(2) A sedimentation basin, here assumed to be 0.5-acres, 5 feet deep with 2:1 sideslopes. Flow into the basin would be via a pipe leading from low-head submersible pumps located just east of the intake. Following is the rough stage-area curve for the assumed basin.



(3) Outflow pump and piping from the basin to the water's destination, not a topic of this report.

The assumed overall annual capacity for the described system would be about 15,000 acre-feet/year, is 20.7 cfs, with an intake peak design capacity of about 25 cfs.

Basin sedimentation analysis is dynamic in the following senses:

(1) Discharge into and out of the basin can vary with time (but doesn't in this study because discharge is presumed to be constant.)

(2) Flow rates into and out of the basin need not be the same (but are the same in this study because the basin is assumed to be always full).

(2) Inflow SS concentration can change (but in this study is assumed constant at 2,000 mg/l).

(3) Surface area changes with stage.

(4) Basin capacity decreases as the bottom accumulates deposition.

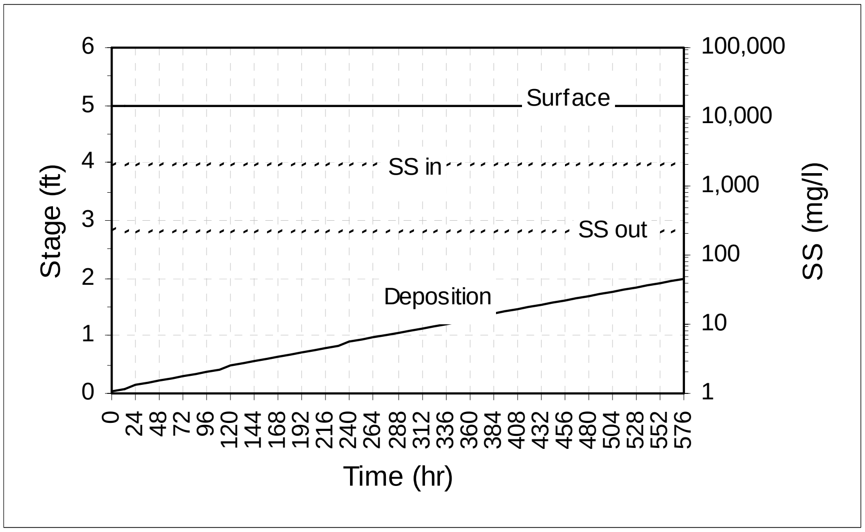
(5) Outflow rate adjusts as necessary to conserve water and sediment. As the basin accumulates deposition over time, its effective water storage decreases.

Sedimentation efficiency is modeled for each of the 11 SS sizes measured at Otowi by the conventional settling/upflow velocity ratio method.

A 0.90 basin efficiency is applied to the overall removal, implying that 10 percent of SS resuspends and leaves with the outflow. This efficiency approximates the performance of a well-functioning urban desilting basin. If inflow is not introduced in a relatively smooth manner and/or the outflow pumping disturbs a significant portion of the pond's quiescence, efficiency should be lowered. Lowered efficiency shifts SS from the basin to the upstream treatment. Lowered efficiency also subjects the pump and upstream piping to more abrasion.

A 0.90 basin efficiency is not the same as decreasing settling velocities by 10 percent, a safety-factor used in some models. The latter adjustment has virtually no effect on this study's performance, where falling 10 percent slower, the particles still reach the bottom. This study's efficiency moves some SS through the basin, independent of particle characteristics.

The following plot shows basin performance for 24 days. The water surface stays at 5 feet while the bed rises 2.0 feet.



Outflow SS varies between 220 and 237 mg/l. Deposition averages 53.8 yards/day. Subsequent water treatment has an additional 6.7 yards/day of sediment with which to contend.

The model run for a longer period fills the basin with deposition -- what common sense says happens. The 24 day run represents as long as the basin might go, on the average, between cleanings. As river SS concentration changes, so does deposition. A more-realistically modeled scenario would show the basin floor relatively unchanged for a period and then sharp rising corresponding to a SS peak in the Rio Grande.

10,000 mg/l SS on the river (seen 1 percent of the May-September days) will fill the basin with 4 feet of sediment in just ten days, however. For the period before the project is brought to full capacity, the rate of filling would be less. Whatever mechanism is chosen to clean the basin must, thus, be always on standby. Cleaning options include:

(1) If the 0.5-acre basin were narrow, its bed could be backhoe-accessible. Excavation equipment could be driven to secure parking.

(2) The bed could be draglined. Fixed equipment will be less secure.

(3) Excavated spoil could be trucked to the nearby Canada Ancha Arroyo alluvial fan. Fifty four yards/day is negligible compared with either the sediment geologically there or the load borne into the Rio Grande in ephemeral runoff events.

(4) Excavated spoil could be trucked from the floodplain. A heavy haul road would need improvement, fuel would be expended and the dumped spoil may have environmental consequence. Long haul trucking will require a full-time driver. If there are nearby large holes to fill, this option may look better.

(5) Excavated spoil could be placed back in the river or along the bank for subsequent erosion. Spoil will generally be between one-tenth and one-hundredth of the SS naturally in the river. Returned spoil would not likely have noticeable geomorphic or significant environmental impact (a topic meriting further description if the option is pursued). Immediate return impacts the smallest riparian area. All river sediment was destined for Cochiti Reservoir before the project. Ending up in Cochiti after the project is, in broad sense, zero change.

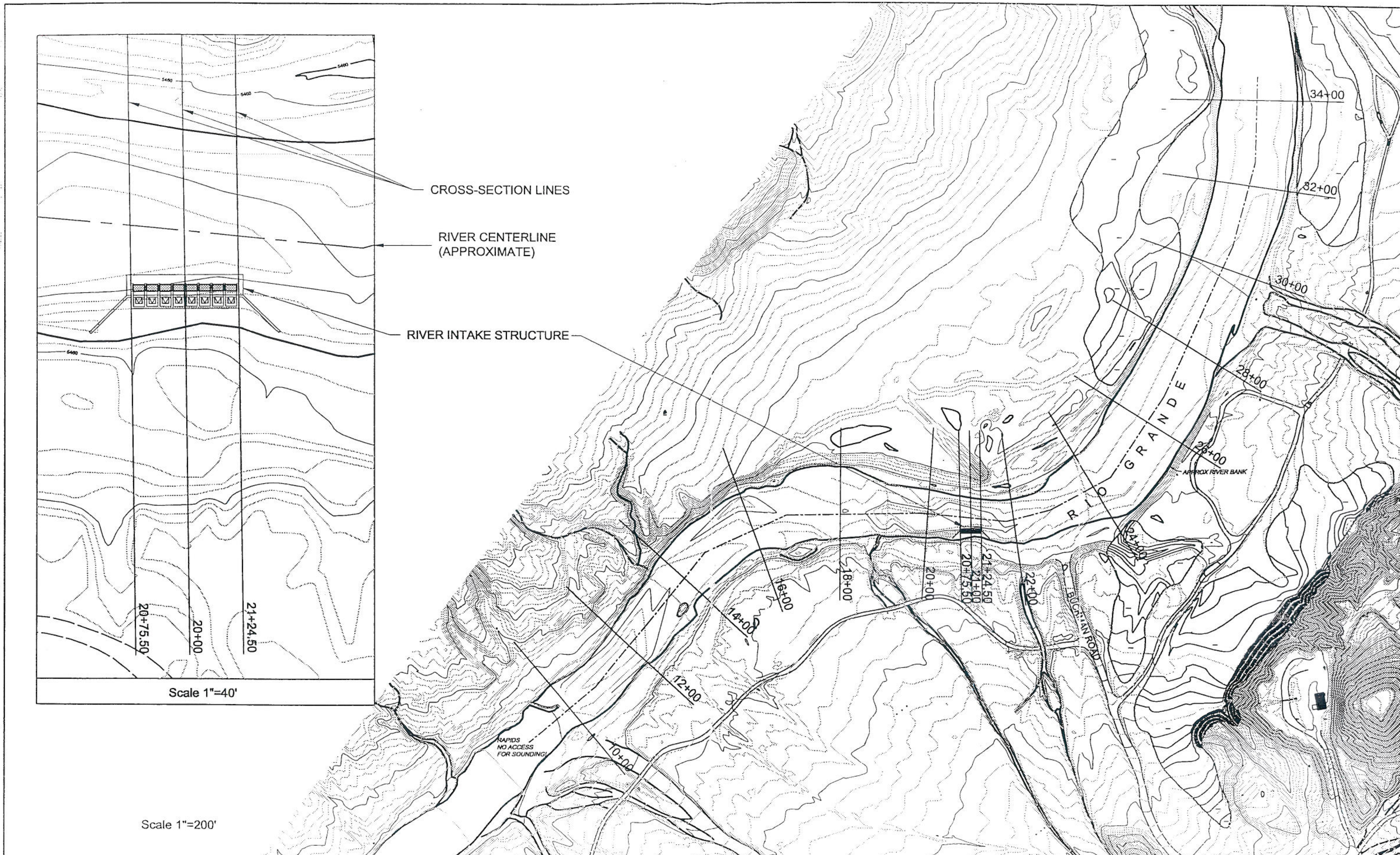
(6) Deposition could be dredged and slurried to its destination, albeit the Canada Ancha, an uphill site or back to the river. Slurrying will have less vehicular impact on the bosque than would trucking, but would leave piping exposed to floods. Slurry water may trigger water rights and environmental issues.

Appendix B.
Channel Hydraulics in Vicinity of Proposed River Intake at Buckman

Rating Table for Proposed Las Campanas River Intake at Buckman

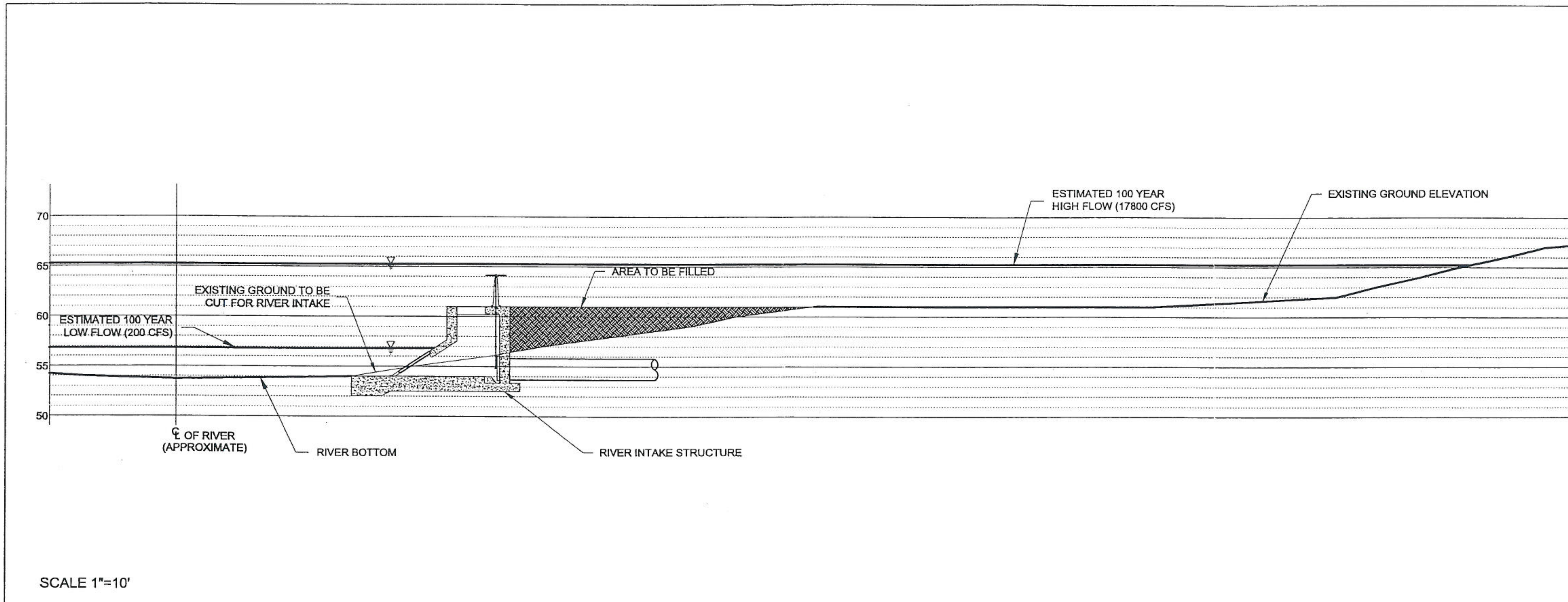
Water surface elevations at the intake based on analysis made by Dr. Richard Heggen using the HEC-RAS hydraulic model and channel topography data are shown on Figure B-1. The 100-year low is 150-200 cfs, wheras 17,800 cfs is the estimate of the 100-year flood. Water surface elevations corresponding to these extremes and other flow conditions are shown below and depicted on Figure B-2. Note that the elevation of the bottom the intake screens is about $5454^{+/-}$.

150 cfs	5456.6′
200	5456.8′
1500	5458.2′
3050	5459.9′
10000	5462.1′
17800	5465.2′
20000	5465.8′



P:\Las Campanas\SURVEY\x-section.DWG

FIGURE B-1 CH2MHILL



CROSS-SECTION OF RIVER AT STATION 21+00 WITH RIVER INTAKE STRUCTURE IN PLACE

P:\Las Campanas\SURVEY\x-section.DWG

FIGURE B-2 CH2MHILL

Appendix C.
Selected Water Quality and Sediment Data for the Rio Grande at Otowi

Water Quality of Rio Grande at Otowi Bridge (1997-1999)

Date	Flow (cfs)	pH	Temperature (C^0)	Turbidity (NTU)	Hardness as $CaCO_3$ (mg/l)	Bicarbonate as HCO_3 (mg/l)	Carbonate as CO_3 (mg/l)	Alkalinity as $CaCO_3$ (mg/l)	Total Dissolved Solids TDS (mg/l)	Total Organic Carbon TOC (mg/l)
11/6/96	610	8.4	6.0	22.0	150.0	169.0	0.0	139.0	261.0	7.2
2/20/97	964	8.3	7.0	7.3	120.0	118.0	2.0	101.0	201.0	8.9
5/20/97	5610	7.8	12.0							
6/10/97	6360	7.3	13.5							
8/20/97	1040	8.1	20.0		98.0	107.0	0.0	88.0	161.0	
9/3/97	1260	8.2	19.5							
11/5/97	1520	8.0	7.0	4.0						
11/18/97	1110	7.3	5.0	4.1						
12/16/97	992	7.8	2.5	3.0	110.0				190.0	3.8
1/21/98	923	7.8	3.0	1.1						
2/5/98	971	8.1	4.0	1.8						
3/3/98	930	7.9	4.5	2.1	100.0				190.0	2.6
4/7/98	1650	8.1	8.5	12.0						
5/12/98	3500	7.6	10.5	13.0						
5/27/98	3650	7.4	12.5	18.0						
6/2/98	3730	7.8	13.0	20.0	90.0				151.0	3.8
7/21/98	1350	8.1	20.0	42.0	120.0				204.0	7.3
8/25/98	1200	8.1	21.0	36.0	120.0	112.0	0.0	92.0	186.0	5.3
9/9/98	1450	8.2	18.0	43.0	110.0				186.0	5.5
10/21/98	883	8.1	11.5	33.0	110.0				199.0	4.7
11/17/98	752	8.3	6.5	17.0	130.0				236.0	3.9
12/15/98	699	8.2	1.0	6.1	140.0				250.0	3.3
1/7/99	761	8.4	3.0	4.3						
1/26/99	864	8.2	3.0	10.0	110.0				197.0	4.6
2/18/99	794	8.4	5.5	7.5	100.0	133.0	0.0	109.0	204.0	2.4
4/21/99	1240	8.4	10.5	400.0						
4/28/99	1220	8.1	12.0	36.0	110.0	125.0	0.0	102.0	202.0	6.9
5/12/99	2760	8.2	10.0		110.0				184.0	8.2
5/26/99	4910	7.9	12.0	75.0	82.0	82.0	0.0	67.0	130.0	9.4
6/3/99	4330	8.2	13.0	32.0						
6/23/99	2900	8.1	18.0		100.0				182.0	7.4
7/16/99	1350	8.6	22.5	30.0	110.0				199.0	5.5
8/12/99	2800	8.2	18.5	22.0	79.0	91.0	0.0	75.0	140.0	6.7
8/24/99	2150	8.3	20.5	27.0	88.0				155.0	5.5
8/27/99	1610	8.1	22.5	14.0						
9/15/99	1530	8.2	18.0	30.0						
9/16/99	1830	8.0	15.5	280.0	76.0				187.0	9.4
Average	*1951*	*8.06*	*11.6*	*40.4*	*107.4*	*117.1*	*0.3*	*96.6*	*190.7*	*5.8*

Table C-1

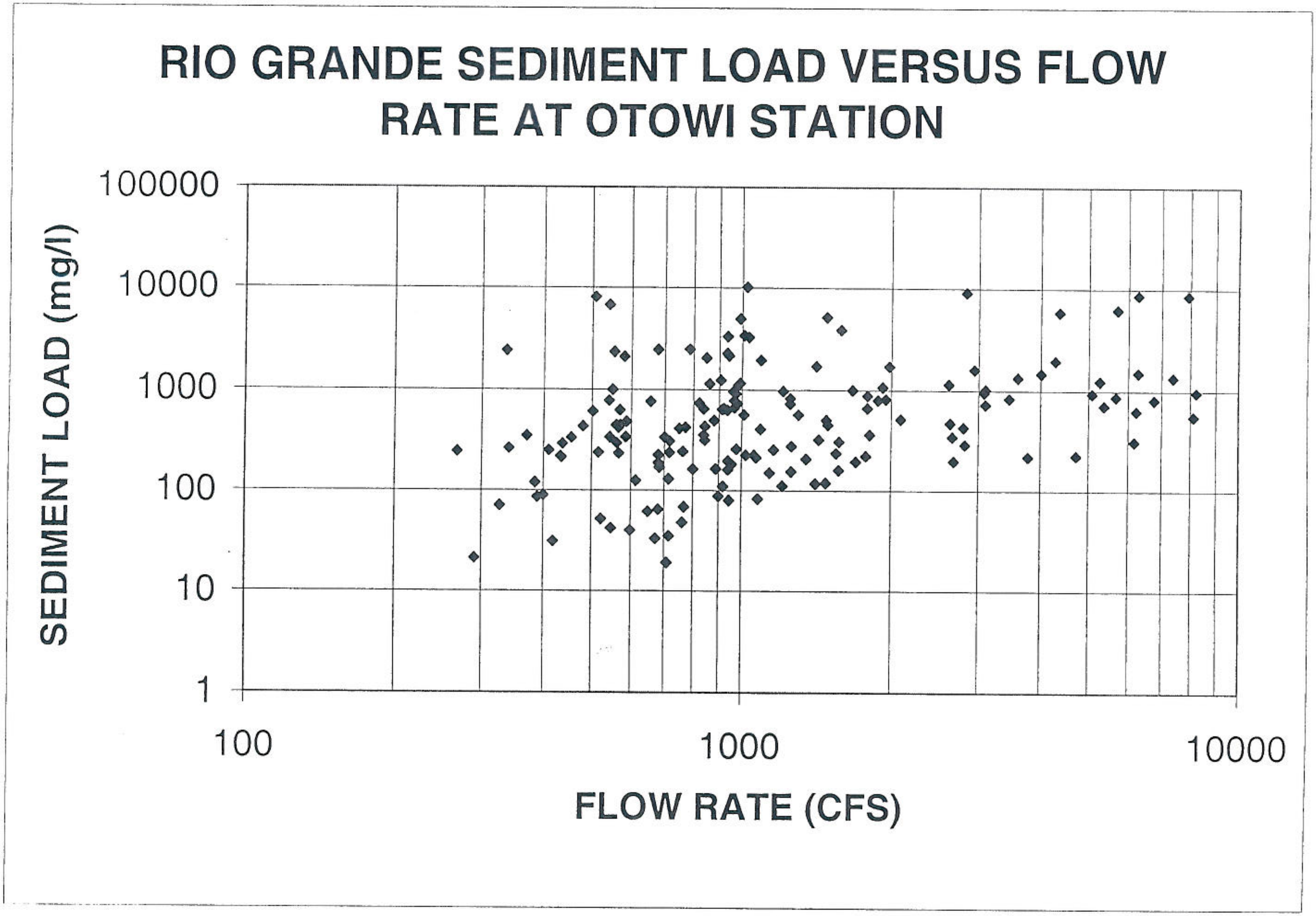

RIO GRANDE SEDIMENT LOAD VERSUS FLOW RATE AT OTOWI STATION
SEDIMENT LOAD (mg/l)
100000
10000
1000
100
10
1
100
1000
10000
FLOW RATE (CFS)

Figure C-1

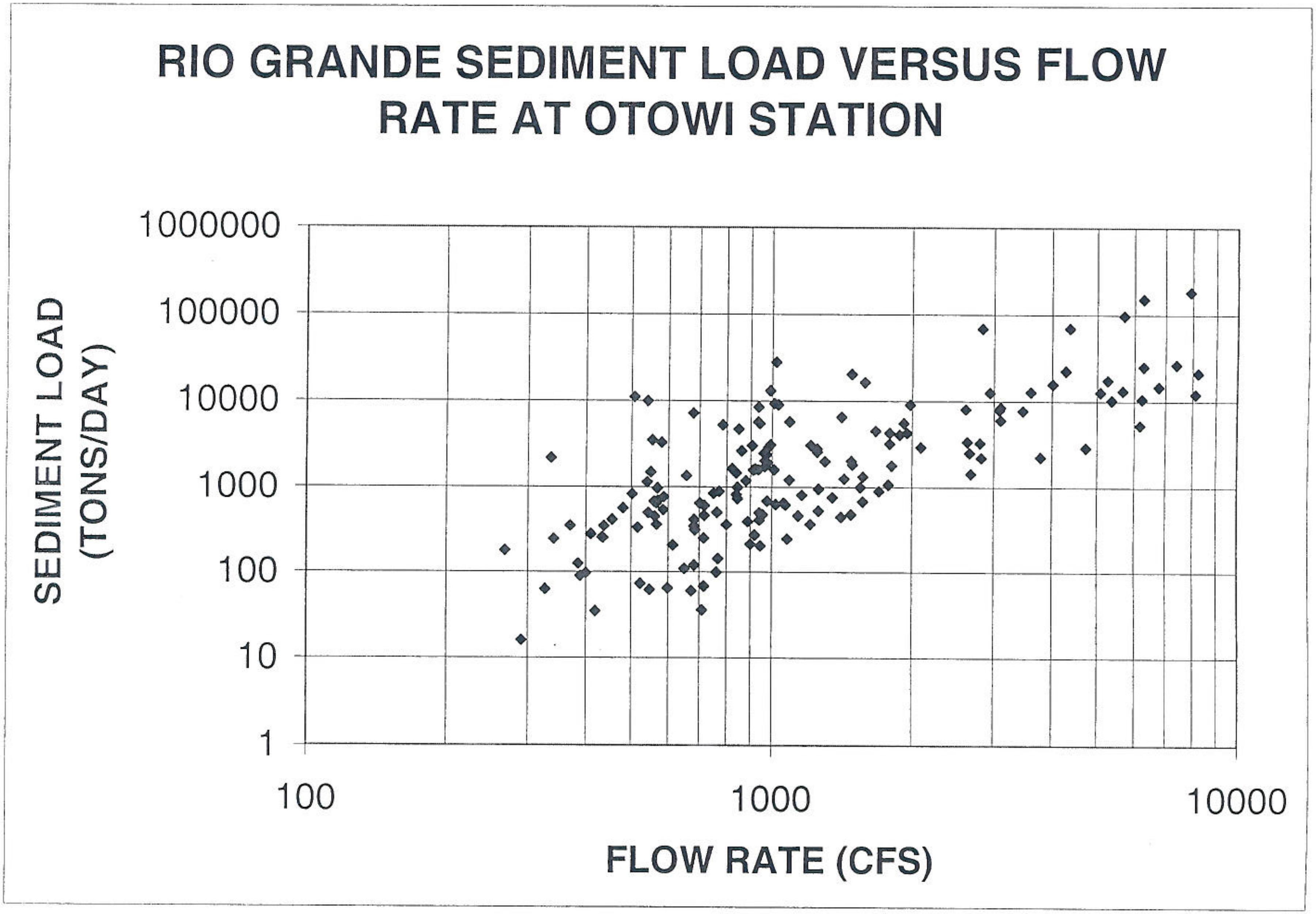
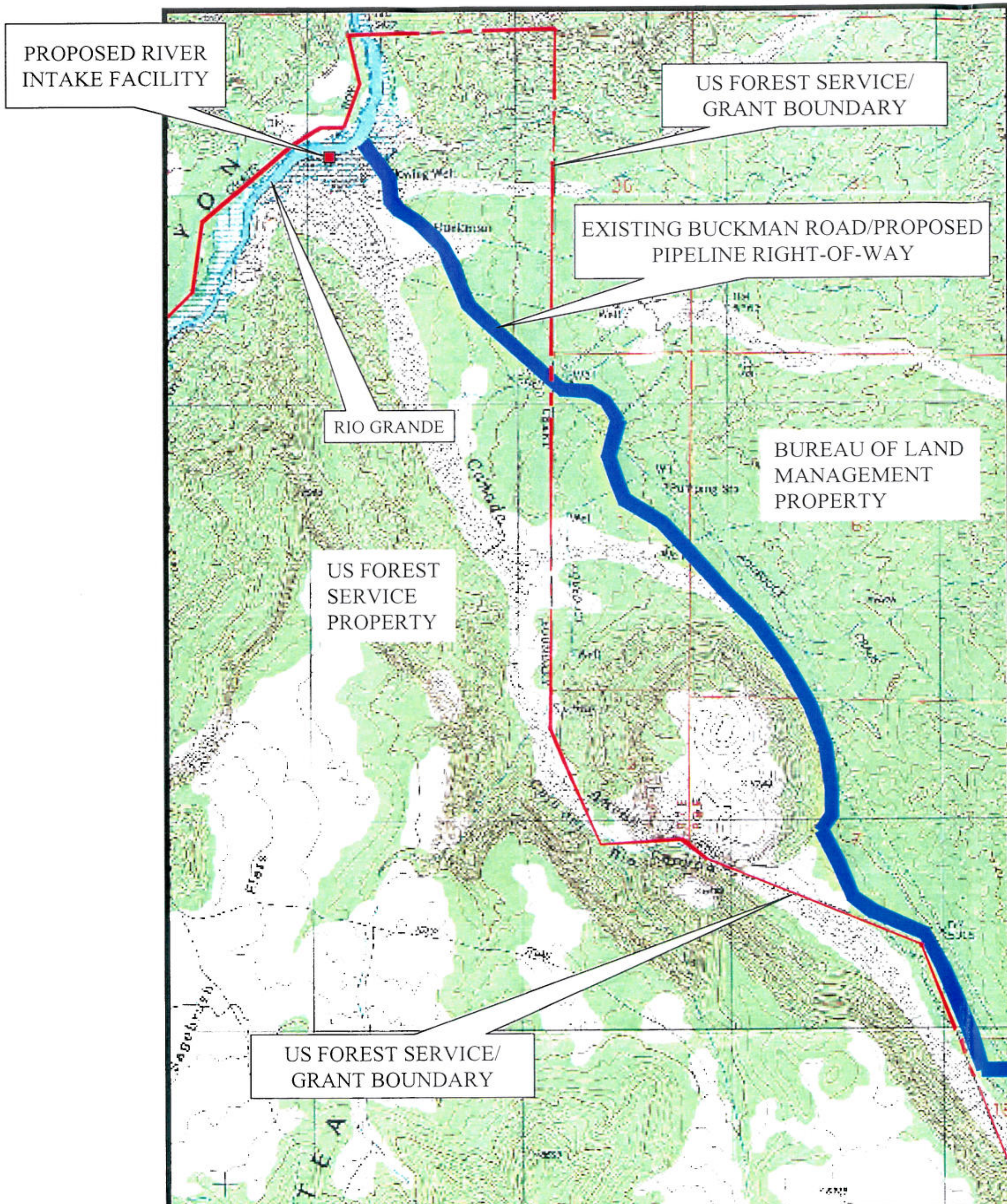

RIO GRANDE SEDIMENT LOAD VERSUS FLOW RATE AT OTOWI STATION
SEDIMENT LOAD (TONS/DAY)
1000000
100000
10000
1000
100
10
1
100
1000
10000
FLOW RATE (CFS)

Figure C-2

Appendix D.
Conceptual Drawings of Proposed River Intake Alternative



ENLARGED AREA MAP

VICINITY MAP

FIGURE D-1

PROJECT LOCATION

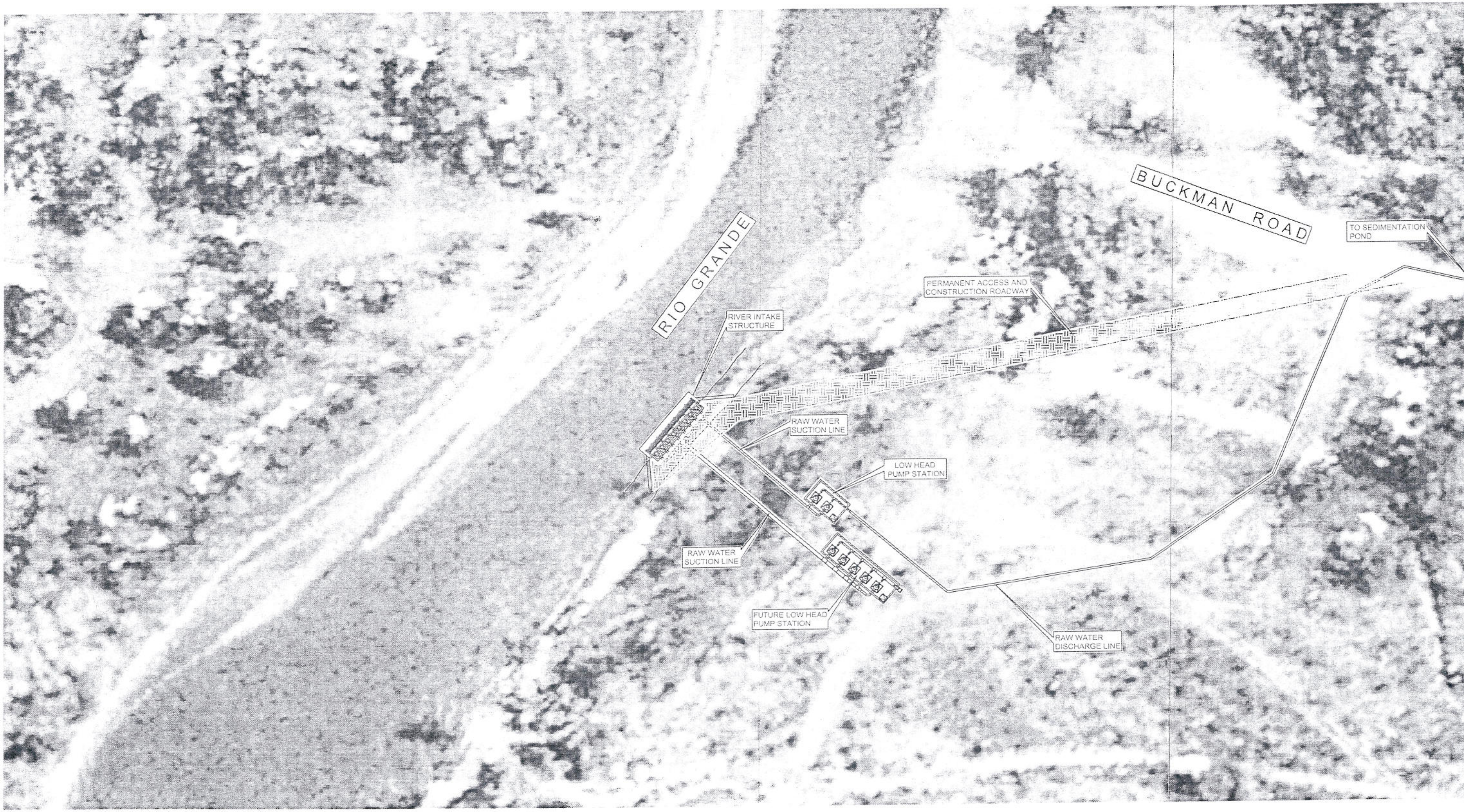


FIGURE D-2

PRELIMINARY
NOT FOR CONSTRUCTION

DSGN JDC						VERIFY SCALE BAR IS ONE INCH ON ORIGINAL DRAWING 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY	
DR EJA							
CHK							
APVD	NO.	DATE	REVISION	BY	APVD		

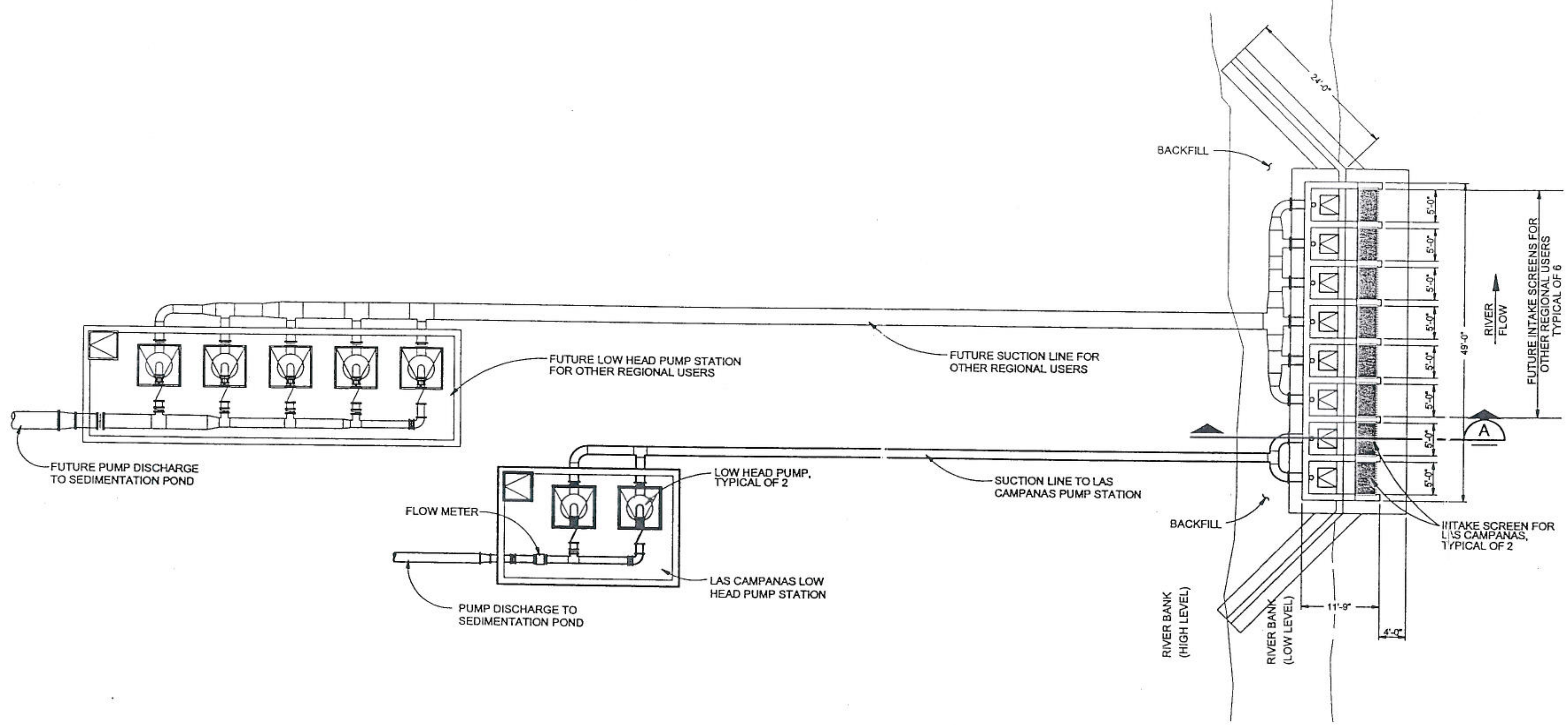
CH2MHILL

SCALE: 1" = 40'

LOS CAMPANAS
REPLACEMENT WATER SUPPLY PROJECT
PROPOSED RIVER INTAKE SITE PLAN

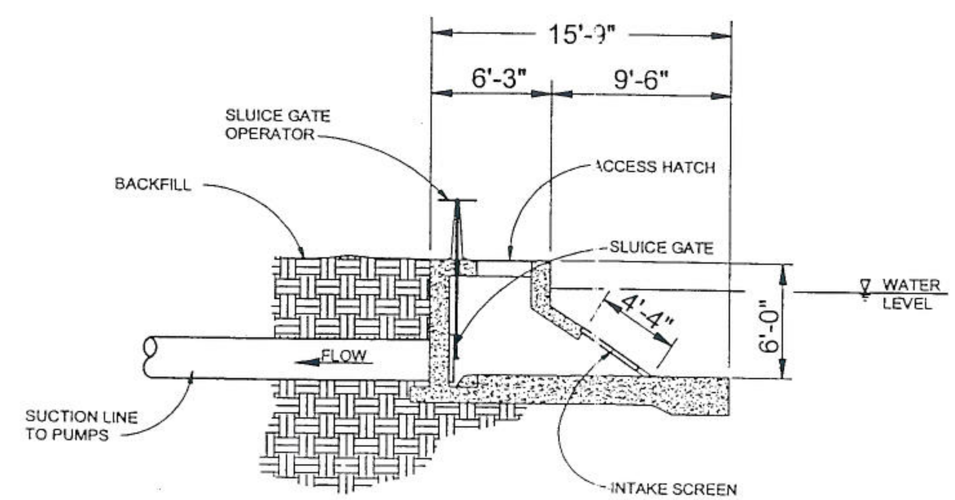
SHEET	Sheet_No
DWG	S-1
DATE	06/27/01
PROJ	-----------

FILENAME: FIGURE_D-2.dwg PLOT DATE: DD-MMM-YYYY PLOT TIME: 00:00:00



RIVER INTAKE AND PUMP SYSTEM (1)

1" = 10'-0"



RIVER INTAKE STRUCTURE SECTION (A)

1" = 5'-0"

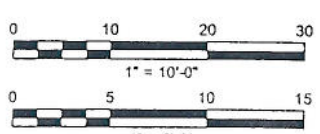


FIGURE D-3

LAS CAMPANAS WATER SUPPLY PROJECT

PROPOSED RIVER INTAKE STRUCTURE

CH2MHILL

FIGURE_D-3.dwg

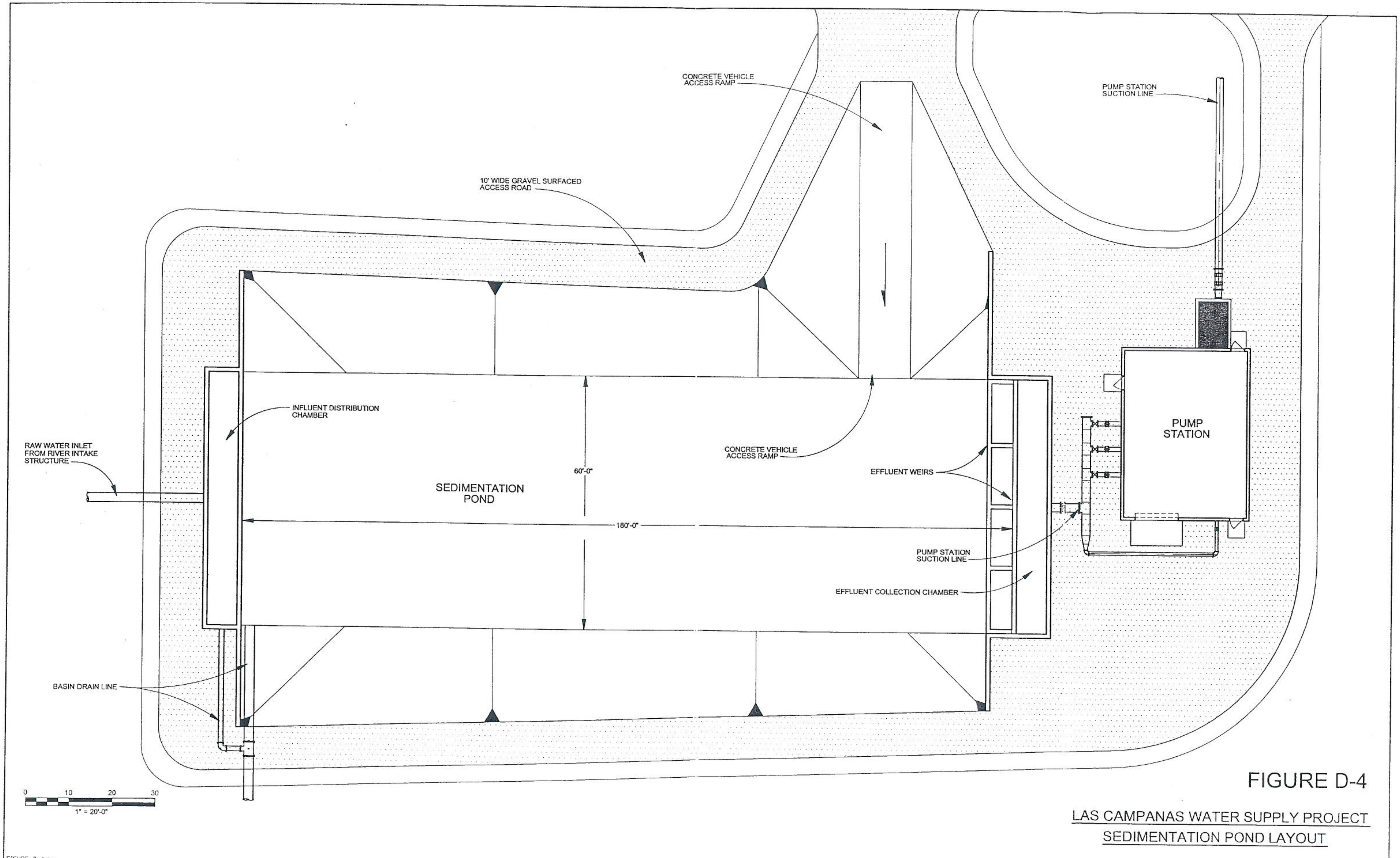


FIGURE D-4

LAS CAMPANAS WATER SUPPLY PROJECT
SEDIMENTATION POND LAYOUT

CH2MHILL

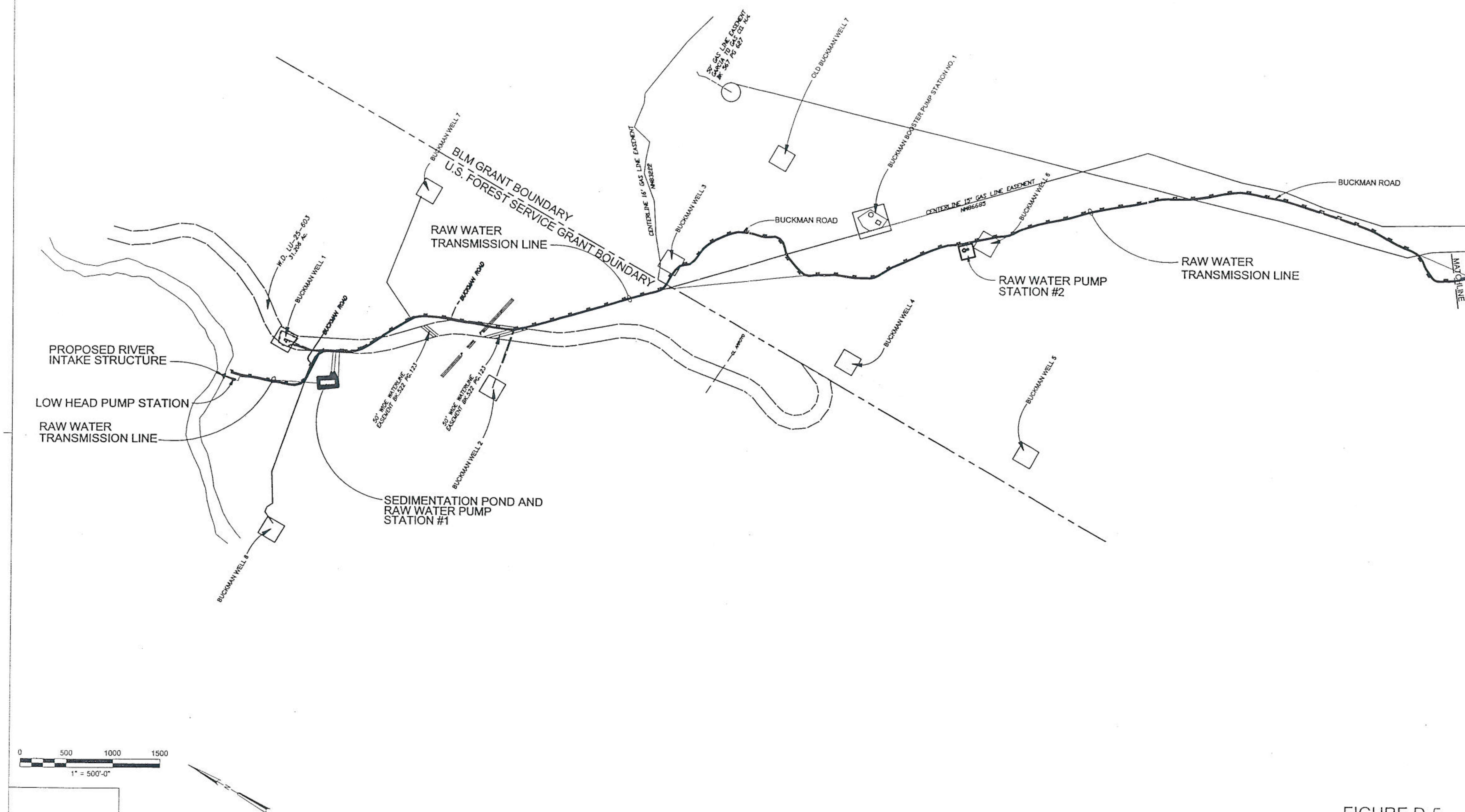


FIGURE D-5

PRELIMINARY
NOT FOR CONSTRUCTION

DSGN	
DR	
CHK	
APVD	

NO	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

CH2MHILL

LAS CAMPANAS DE SANTA FE
REPLACEMENT WATER SUPPLY PROJECT
PROPOSED WATERLINE ALIGNMENT
STA. 0+00 TO STA. 145+00

SHEET	1
DWG	C-1
DATE	5/11/2001
PROJ	162065

FILENAME: FIGURE_D-5_9.dwg PLOT DATE: DD-MMM-YYYY PLOT TIME: 00:00:00

FIGURE D-6

PRELIMINARY	DSGN		
NOT FOR CONSTRUCTION	DR		
	CHK		
	APVD		

NO	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

LAS CAMPANAS DE SANTA FE
REPLACEMENT WATER SUPPLY PROJECT
PROPOSED WATERLINE ALIGNMENT
STA. 145+00 TO STA. 309+00

SHEET	2
DWG	C-2
DATE	5/11/2001
PROJ	162065

FILENAME: FIGURE_D-5_9.dwg PLOT DATE: DD-MMM-YYYY PLOT TIME: 00:00:00

FIGURE D-7

PRELIMINARY
NOT FOR CONSTRUCTION

DSGN	
DR	
CHK	
APVD	

NO.	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

LAS CAMPANAS DE SANTA FE
REPLACEMENT WATER SUPPLY PROJECT
PROPOSED WATERLINE ALIGNMENT
STA. 309+00 TO STA. 490+00

SHEET	3
DWG	C-3
DATE	5/11/2001
PROJ	162065

FILENAME: FIGURE_D-5_9.dwg PLOT DATE: DD-MMM-YYYY PLOT TIME: 00:00:00

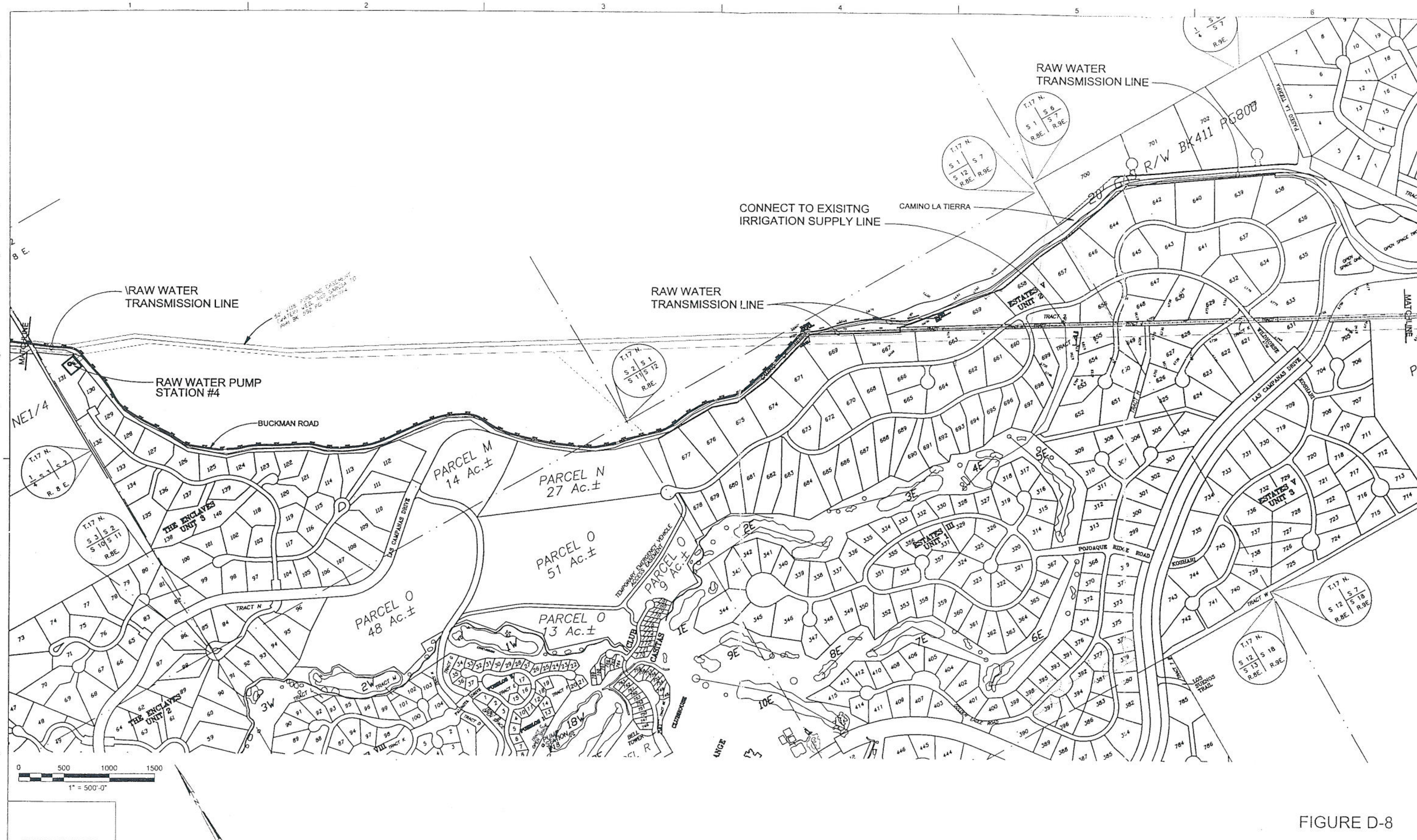


FIGURE D-8

PRELIMINARY

NOT FOR CONSTRUCTION

DSGN					
DR					
CHK					
APVD	NO.	DATE	REVISION	BY	APVD

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

LAS CAMPANAS DE SANTA FE
REPLACEMENT WATER SUPPLY PROJECT
PROPOSED WATERLINE ALIGNMENT
STA. 490+00 TO STA. 67+00

SHEET	4
DWG	C-4
DATE	5/11/2001
PROJ	162065

FILENAME: FIGURE_D-5_9.dwg PLOT DATE: DD-MMM-YYYY PLOT TIME: 00:00:00

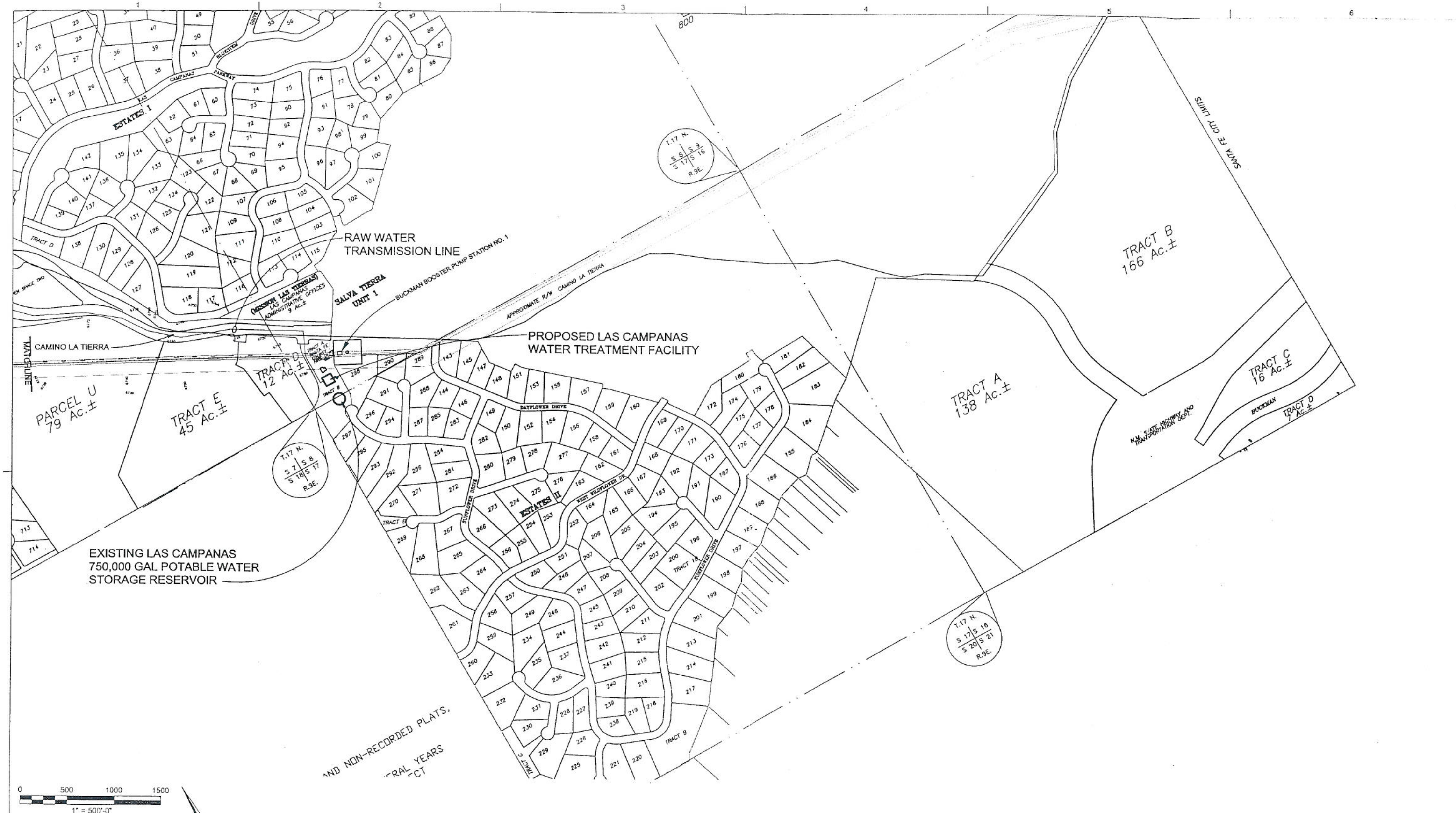


FIGURE D-9

PRELIMINARY NOT FOR CONSTRUCTION	DSGN / DR / CHK / APVD	NO. / DATE / REVISION / BY / APVD	VERIFY SCALE: BAR IS ONE INCH ON ORIGINAL DRAWING. 0 — 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	CH2MHILL	LAS CAMPANAS DE SANTA FE REPLACEMENT WATER SUPPLY PROJECT PROPOSED WATERLINE ALIGNMENT STA. 67+00 TO STA. 100+00

SHEET	5
DWG	C-5
DATE	5/11/2001
PROJ	162065

FILENAME: FIGURE_D-5_9.dwg PLOT DATE: DD-MMM-YYYY PLOT TIME: 00:00:00

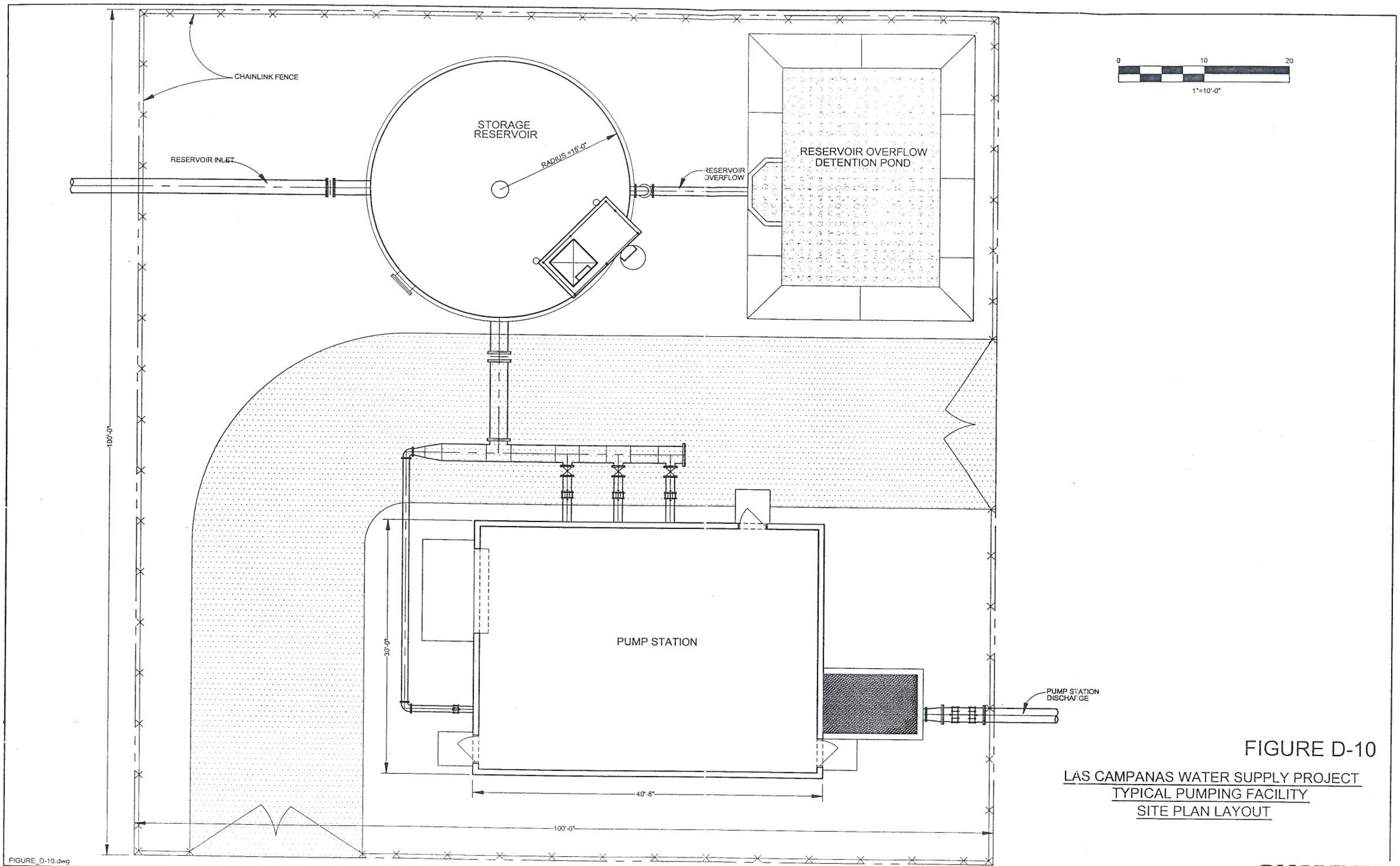


FIGURE D-10

LAS CAMPANAS WATER SUPPLY PROJECT
TYPICAL PUMPING FACILITY
SITE PLAN LAYOUT

CH2MHILL

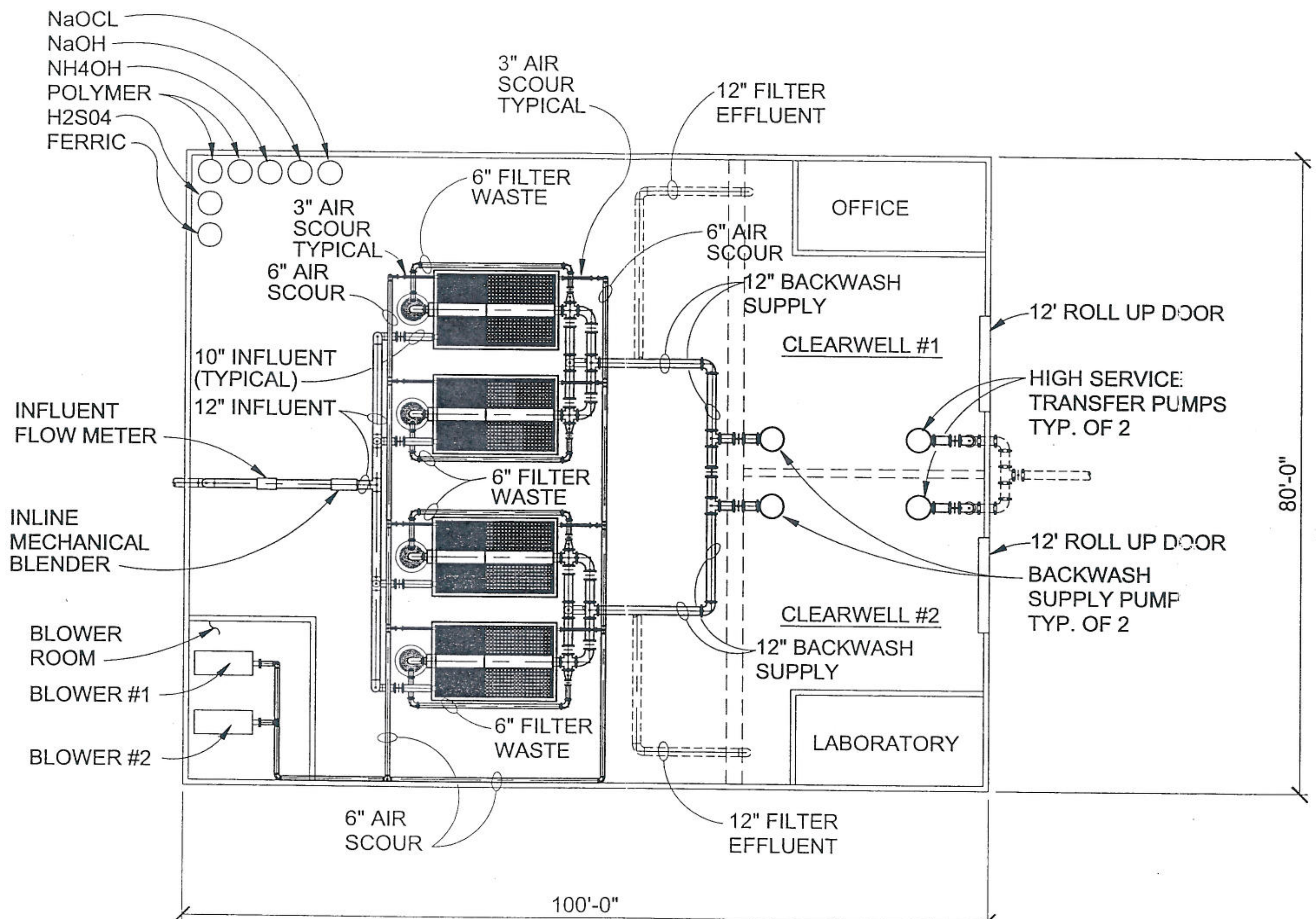


FIGURE D-11

LAS CAMPANAS WATER SUPPLY PROJECT

TYPICAL WATER TREATMENT PLANT

CH2MHILL

WTP-layout.dwg

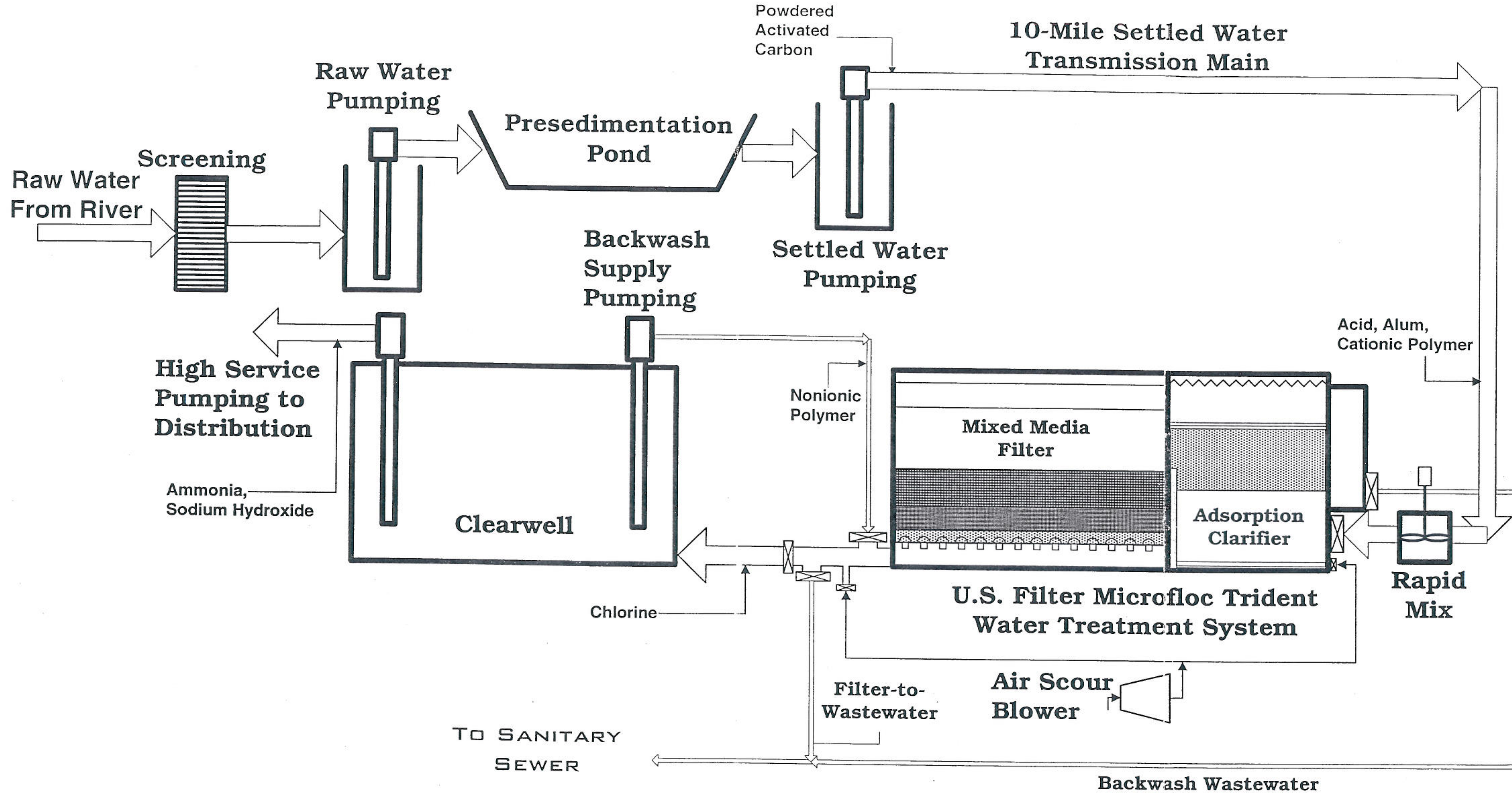


Figure D-12
LAS CAMPANAS CONCEPTUAL
WTP PROCESS FLOW DIAGRAM